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Talking about science? A study of the nature of discussion carried out when students work in small groups in the secondary science classroom.

DOCTOR OF EDUCATION (EdD)

2006

ABSTRACT: This research focuses on small group work and talk in the science classroom. Peer collaboration is considered important in supporting learning and as a means of generating cognitive conflict in the science classroom for the individual; often the social aspects of this collaboration are overlooked. There is little practitioner research in this area and this project seeks to describe, in detail, the classroom talk carried out by two groups: Group A, a single sex group of boys and Group B, a mixed sex group. It focuses on the type of talk carried out by the students using the categories of: exploratory, cumulative, disputational, off task and technical talk and examines the impact that these have on learning and group relationships. Social roles and their impact on classroom talk and learning are also examined; adopting different social roles being the means by which differential expertise and scaffolding develops within the groups. Gender issues are also examined when students work in small groups in the classroom. All of the above analysis helps to describe these groups in detail and go on to put together a framework of advice for teachers in the classroom on the setting up and monitoring of small group work to maximise the potential, small group work has, for the development of conceptual understanding in science.

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Jane Tinker
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April 2006

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For my children; Eleanor, Joe and Madeleine who I hope will always have the courage to rise to challenges and finish those that they start with the certainty that my love and support is always there for them.

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For my Mum; there aren't enough words to express my gratitude for all of her love and support over all of the years, with Dad she always will be the foundations that the rest of my life has been built upon. Foundations of deep and enduring love, belief in my abilities, loyalty, encouragement and great faith. This work and my qualification are dedicated to her with my love. xxxxx

EX12

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Chapter 1 Introduction

Introduction to the thesis

My study aims to provide a detailed analysis of the ways in which students work together, in small groups, in the science classroom. In particular, I am interested in studying the effect of an intervention and its impact upon students' learning. This intervention involves increasing the amount of time the students work in small groups, in my own class, and encouraging them to talk about specific science tasks. Following this intervention, the research questions I am addressing are:

- What is the language used by the students when they work together in small groups to complete specific science activities? What are the types of talk that develop and how do these contribute to learning in science?
- How do the groups work together and what is the effect of the social relationships they develop and the social roles they adopt on their talk and their learning in science?
- What is the nature of the communities that develop? Do they have similarities with *community of learners* (Rogoff 1994)? What is the impact of the communities that develop on the talk found in the groups?

Many authors have discussed group work in science, with a particular focus on language and conceptual change and the role that language has in the development of scientific understanding. In the EPPI review (2005) one of the factors identified for research is the effect of small group discussion on '*students understanding of scientific ideas' (p.2).* This research project aims to make a contribution to this debate looking at the ways in which talk and the social nature of small groups may affect this; how is the talk used in this science classroom and in these small groups to support the learning of the students. This is of particular relevance at this time with the new G.C.S.E. specifications advocating small group work as pedagogy appropriate in

supporting students' development of their scientific literacy; that is enabling young people to understand the scientific issues that may influence their everyday lives; two typical examples of this being pollution or genetically modified foods. New courses have been designed with this pedagogy in mind, including 21st Century Science and Science for Public Understanding. Clearly, if students are to learn how to interpret science and scientific issues in their everyday lives, through the use of small group work, then this will happen best if they have the skills needed to talk successfully in small groups. My study aims to contribute to this debate by indicating how teachers may organise small group work in the classroom and what factors may need to be considered.

Research into language and conceptual change can overlook the important social issues that develop when students work in small groups, as I will go on to show. From a social constructivist perspective language and interaction with others is the means by which understanding develops therefore, anything that may affect this talk or these relationships needs to be explored. This study seeks to examine the nature of *communities of learners (*Rogoff 1994) as they may exist in this classroom. The approach to learning taken in this study is a socio-cultural perspective, where children learn through collaboration with their peers during their scientific activity. It is the nature of this collaboration that is explored. This is an important issue, if teachers are to be provided with advice to help them develop the idea of *communities of learners* in their own classrooms and to be able to use small group work successfully as a pedagogical approach. This is important in my classroom, where I seek to use small group work to support learning in science and so support the students' learning in a social constructivist and socio-cultural way; through their talk and interactions with their peers.

There has also been research into social roles when students work in small groups in the science classroom but little research that aims to look at both issues; the language used in small groups with the contribution this makes to

learning and the social issues associated with adolescents working together. This research also examines whether gender impacts on learning in small groups and whether this affects the students' talk, development of social roles and the implications of this for learning. This is important within this science department which has a policy of seating Year 7[1] classes with boys next to girls.

There has been little practitioner research in this area; practitioner research is important because, as an *insider,* the teacher has the potential opportunity to investigate a real classroom setting without the possible effect that another researcher in the classroom may have upon the way in which the students act and therefore the data collected. This point is supported by Blatchford and Baines (2002) who note the enormous potential of group work for learning with an observation that what is needed in *'an appreciation of group work in authentic classroom contexts' (p.2),* this practitioner research aims to do just that. The *authenticity* of this data and the insight that I have, as a teacher carrying out research to provide advice for other teachers, supports a view that practitioner research has a valuable contribution to make to the wider field of educational research. Within the context of this science department the findings of this research will be used to review current department policy related to classroom organisation; specifically, the seating of students with boys next to girls, and to provide material for discussions related to how students learn in science and appropriate pedagogical approaches that teachers can adopt to support this.

Chapter 2, in reviewing the literature, goes on to focus on group work which has been widely discussed and has been associated with research in the following fields:

- Learning theories, especially those which stress the importance of language and communication in the development of understanding,

[1] First year secondary students aged 11-12.

particularly the work of Vygotsky and social constructivist and socio-cultural perspectives on learning.

- Science education, where group work has been associated with development of scientific understanding and as a means of generating *cognitive conflict*, drawing on a cognitive constructivist view related to a Piagetian tradition.
- Research into collaboration where researchers have defined how small groups may collaborate in practice and have identified the types of talk that collaborating small groups may be involved in.
- Social roles and relationships and the impact that these have upon the type of small group that develops and the effect that this has on learning. Conflict, group type and leadership have all been found to be interesting features of group work in the classroom.
- Gender issues, where group work seems to be related with achievement and emotional development.

Chapter 3 focuses on the context of the study, its methods and methodology. The study took place in a large, oversubscribed secondary school science department. My role within that department was that of a science teacher. An ethnographic case study approach was adopted where the two groups' talk was studied in depth, with the data coming from a real classroom context and being collected in a relatively informal way. The data analysis takes the form of descriptions with some statistical analysis of the talk.

The observations themselves took place during the students' first term in secondary school. Four activities were focussed upon in the *Substances* scheme of work and planned with specific opportunities for the students to talk in small groups. The students organised themselves into groups of four and a mixed sex group and a single sex boy group were selected randomly (from a class of 28 students) for the purposes of this study. Activities 1 and 2 gave opportunities for the students to talk about their observations from a practical activity and to develop a conclusion about their experimental results; the students were involved in investigative science. Activity 3

engaged the students in summarising information about the topic they were studying and during Activity 4 the students used revision questions to review the topic prior to their end of unit test.

Chapter 4, the data analysis chapter, discusses the findings of this research providing evidence from the data and descriptions of the group talk. The aim of this chapter is to summarise the findings of Group A, the group of four boys; Sam, Dale, Liam and Stephen and Group B, the mixed sex group of two girls and two boys; Robert, David, Cassie and Sarah.

In the final chapter, Chapter 5, I move on from the data to provide advice for practitioners who wish to use group work as a pedagogical approach to support learning in their own classrooms. I discuss how teachers can monitor the talk taking place and give indications of what might count as successful talk in small groups. I focus on the conditions needed to encourage *cumulative* and *exploratory talk,* as a means of developing conceptual understanding in science.

I also look at how group discussion can be used successfully with single sex small groups and propose guidelines about how talk in mixed sex groups may be improved. In short, what are the conditions for successful small group work in the classroom and what is it that teachers should avoid.

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Chapter 2 Literature Review

Introduction

This chapter reviews the literature surrounding the issues used to analyse the data in this research. I start by exploring the way in which influential researchers in science education have based their pedagogy in a Piagetian tradition. Moving on to comment upon the emphasis on language as a means of developing *cognitive conflict* in Piagetian constructivism and the problems that are caused when this thinking does not take into account the influences of others on learning and the very social nature of learning itself. Social constructivism and the ideas of Vygotsky are discussed focussing on the role of language as an *intermental* and *intramental* feature in learning. A definition is provided for a socio-cultural perspective of learning, the ideas of *communities of practice, guided participation* and *communities of learners* being explored. It is important to consider these theories of learning to provide a context within which to review the talk taking place in these small groups and to describe and consider how it may be contributing to the learning of the students. The role of talk in the learning theories above and in these small groups needs to be compared. The research question addressed here is how do the students use language to support their learning in science and it is only through an appreciation of what the learning theories have to say about the role of language that this can be achieved.

The next section provides a definition for *collaborative learning,* as it is used for the purposes of this research and explores the different types of talk evident when students work in small groups in the classroom, focussing on the impact that these types will have on developing collaborative group work and *interthinking* and *exploratory talk* as the goals of group work to support learning within a socio-cultural framework. A consideration of collaborative learning, and the types of talk that can indicate this, is needed to provide full and detailed analysis of the two groups examined in this research. The nature of their collaboration and the factors that affect it will

help in the development of an advice framework for teachers. The research question being addressed here is how do the students work together, this is further refined as a description of the collaboration as it is found within their groups.

Next, group development is discussed exploring how groups go about developing in collaboration and how collaborative group work and types of small social groups can be identified. This includes the social roles that group members can demonstrate with the impact that this will have upon the development of *exploratory talk* and *interthinking*. Leadership issues and conflict will be discussed, how to identify these in small group talk in the classroom and the impact they have upon this talk and it's role in learning. This is needed to address fully the research question of how do the groups work together. It is vital to be able to understand some of the group processes that are analysed in the data. The social relationships and social roles that the students adopt may have an impact upon their learning and the type of talk and collaboration they are engaged in. Previous research provides a framework within which to consider the group processes that may be found in small groups of adolescents when they work together in the classroom.

Finally the problems associated with group work, particularly focussing on gender issues arising when students work in mixed and single sex groups and the impact that these gender issues have on learning. This is an important issue for this project as it is the current department policy to seat students next to members of the opposite sex.

The effort here is to create a language and conceptual framework for discussing and analysing group talk in science education. Looking at how this talk contributes to the students' learning in science and whether there are factors in how the groups are organised, their social relationships or the tasks that affect this.

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The role of language and communication in learning

Research into science education still has conceptual development as one of its major focuses (Tsai 2005). Within this, the alternative conceptions of students and how to change these are still a topic for discussion. During the 1980s and 1990s the focus of this was in terms of Piagetian constructivism (e.g. all the research on misconceptions and associated pedagogy of CLISP[2]). Furthermore when talk is considered in a major programme like CASE[3] (still a major influence as a means of raising achievement in science today) it is seen as a mechanism by which cognitive conflict is created, for the individual and often the impact of social aspects of talk are not fully considered. Piagetian constructivism has been very influential in science education as a way of analysing how students learn scientific concepts; key writers such as Harlen (2000), Driver (1988) and Adey & Shayer (1989) have supported this view.

The *Thinking Science* materials of the CASE project were developed and located in a Piagetian constructivist model of learning. The focuses of the CASE programme being to challenge the misconceptions of students through their interaction with practical tasks. For Piagetian constructivists, learning places emphasis on the individual as an active constructor of meaning. The learner achieves this by testing his/her ideas against evidence. It is through these interactions with the environment that it becomes possible for the individual to construct conceptual understanding. The view of Piagetian constructivism is that concepts evolve and develop over time; knowledge is built when new experiences challenge existing frameworks of understanding and a period of *disequilibrium (cognitive conflict)* occurs leading to changes in the models that individuals use to understand the world. In the classroom, central to the development of the child's knowledge and understanding about science is the child's interaction with the task set up by the teacher to challenge any misconceptions the child may have and therefore enable the child to learn; a key element of the CASE approach to science teaching. The task has to challenge current

[2] Children's Learning in Science Project
[3] Cognitive Acceleration in Science Education

frameworks for understanding (that is bring about cognitive conflict) but the role of other learners/experts is seen mainly as a means of generating cognitive conflict for the individual, small group work is used as a means for this to occur. Every CASE lesson follows the same structure; whole class discussion is used at the start to introduce the activity and technical vocabulary needed and to elicit prior understanding. Then in the second phase of the lesson small group (3-5 students) activity is carried out with talk used to mediate the students' ideas. Here this peer interaction creates *cognitive conflict* in the individual mind. Although social interaction is needed for learning to take place, the individual is interested in acquiring this knowledge for him/herself. The small groups then feed back their ideas to the whole class for further mediation to occur and for *cognitive conflict* to be resolved. It is during this phase that the students can internalise their ideas or the better ideas of other peers. The final part of a CASE lesson is a *bridging* activity, which looks forward to what the students will do next, to extend the context for their understanding, or links to another *Thinking Science* activity. I will go on to show that this approach under-rates the role of language as Piaget did, and in particular the social aspects of it. Other things may be occurring during small group work and not just the creation of *cognitive conflict.*

Moving more up to date Harlen (2000), is another key influential writer in science education. Again, her theory of how children learn in science is based in Piagetian tradition. She supports a view that activities should be based in everyday experience so that interest is maintained and that learners should be addressing their own questions and taking responsibility for their own learning; thus implying the individual nature of learning. Attention should be given to *process skills*; the means for acquiring conceptual understanding (Process skills have a role in developing *procedural understanding* and therefore *conceptual understanding* as is said to occur in CASE lessons). Harlen goes on to describe the purpose for these *process skills*:

It is through their use that scientific ideas are tested, developed and linked with other ideas and become part of an individual's way of making sense of the world. (Harlen 2000 p. 181)

The key *process skills* for Harlen are the ability to observe, ask questions, hypothesise, make predictions, collect and interpret evidence. As well as these process skills, other different skills are needed, the students also need to share ideas, listen to other points of view and test ideas of their own or others. She explores the role of the teacher as a provider of opportunities for children to develop these skills and encourage them to discuss their thoughts in small groups with their peers in order to bring about *cognitive conflict*. Teachers should talk to the children about the processes that they have used in order that they can best help children develop their skills. The teacher should improve children's abilities to make predictions and test their predictions against evidence, interpret and communicate their interpretations with others; this has similarities with the pedagogy adopted in CASE. Again the focus by Harlen is on the individual learner appropriating knowledge for themselves.

Harlen does explicitly consider the importance of talk in the science classroom, using Douglas Barnes' idea of *speech as reflection*. It is, in her view, important for the discussion of scientific ideas in the classroom that *speech as reflection* is encouraged; this can also be thought of as *thinking out loud*. Barnes and Todd (1977) note that teachers should allow children to think out loud and use the language appropriate to them to do this. Harlen considers that children have to be able to use disjointed utterances and language that may be difficult for others to understand in order that they improve understanding for themselves (resolve their own *cognitive conflict*). Barnes and Todd describe this as *exploratory talk*, talk that will help children build on and develop their existing frameworks for understanding. For Harlen small group discussion, *cognitive conflict* and its resolution,

takes place during practical activities where children should be encouraged to fully discuss their ideas with their peers.

In summary, Harlen views the importance of talk as being a way that children can clarify their ideas for themselves and share their ideas with others (resolve cognitive conflict to bring about learning). For Harlen, although language is seen as important, it is used is by the individual to help them develop their own understanding of science.

Moving on from looking at how Piaget has influenced ideas about teaching science, I go back to look at where these ideas came from and discuss Piagetian staged theory, where the individual is seen as proceeding through a series of developmental stages. This is discussed to review how his work has been used by key researchers in science education and what Piaget did, or did not have to contribute to the debate about the role of language in learning. Piaget described in detail for his subjects:

> *like a series of stills from a movie, all the steps of knowledge development all over the psychological spectrum from birth to adulthood* (Shayer 2003 p.476)

Piaget tested learners, over a range of tasks, and found that learners failed at them if they were above what he considered to be the developmental stage the child was at; this developmental stage being closely linked with the child's age.

One problem for Piaget, as described by Rogoff (1990), is that Piaget examined how individuals adapt to the environment, where his main emphasis was placed upon looking at how individuals make sense of the world in a general sense as a species. Piaget thus assumed that individuals would adapt to the world in the same way independent of the specifics of the environment. Rogoff asserts:

> *Piagetian theory is based on the species- typical genetic background and the species-typical environment, which together form the basis of the individual's effort to construct an understanding of reality.* (Rogoff 1990 p.31)

Piaget does accept that the individual cannot be separated from the action of the environment and he describes organism and environment as an *indissoluble entity* (Rogoff 1990 p.31). This idea does not take into account the fact that every *indissoluble entity* is different from any other, because every individual is different and every individual may perceive the same environment in a different way.

Writers such as Donaldson (1978), Mercer (2000) and Rogoff (1990) have disputed Piaget's findings, or at the very least, have drawn attention to aspects of the child's world that Piaget may have overlooked. For Mercer (2000) it is the role of adult-child conversation that Piaget may not have considered in enough depth:

> *Young children's direct experience of the world usually takes place in social settings, and it often accompanied by talk about it. What is more conversation is one of the more important kinds of experience that children have; there is no reason to think that the information they gain through it is any less significant than that obtained by other means (such as seeing, touching and so on).* (Mercer 2000 p.136)

Here Mercer notes that Piaget, in neglecting to investigate relationships with others, may have missed important evidence about the way in which children learn. Cognitive conflict can be brought about through language and relationships with others just as much as it can through interacting with the physical aspects of the world, a point noted by the CASE approach and included within their lesson structure. Language has a role in instigating cognitive conflict as well as resolving it; it is not just interacting with the

physical environment that is important but using language to test your ideas against those of another person.

Donaldson (1978) considers lack of effective communication as one possible explanation of why children failed at standard Piagetian tasks, for example class inclusion tasks. Isaacs, Donaldson and McGarrigle claim that it is not that children fail to reason and therefore fail at the tasks, but that they fail to understand what it required of them to succeed; it could be considered that they did not know what they had to do. This work has disputed Piaget's ideas on the staged nature of development. When the context of the child and the experimenter was the same, that is they understood each other fully, children were found to succeed and reason beyond the developmental stage assigned them by Piaget. For example, Piaget's class inclusion tasks were repeated using subtle changes to the language of the questions asked by the experimenter. Donaldson offered a possible explanation that children failed at these class inclusion tasks when:

> *The children did not know what the experimenter meant; and one is tempted to say they did not strictly appear to know what the language meant.* (Donaldson, 1978, p.46)

It would seem from the work of Donaldson, that language and the way that tasks are set up for learners could affect their success. We need also to take into account the child's perceptions of the adult and why the adult may be asking the questions. Children have learnt, through their relationships and communication with adults in learning situations, that the adult most of the time, knows the answers to the questions they are asking and this may lead the child to draw inferences from what the adult is saying; that is give the adult the answer the child thinks that he/she wants. The communication that takes place between the adult and the child in these tasks seems central to the child's success. Piaget who placed less emphasis on communication with others may have underestimated this.

Shayer (2003) argues that Piaget has, mistakenly, been considered to focus on individuals, whereas his methodology focused on individuals and by the nature of the methods used it was not the case that Piaget failed to comment on collaboration in learning it is that he did not investigate it (this point is also made by Rogoff (1990)). The same methodological reasons can be given as an explanation to why children failed at tasks with Piaget but succeeded with McGarrigle. The Genevan methodology adopted by Piaget meant that while the child was carrying out the task the adult was not to offer any help (McGarrigle's methodology allowed mediation to take place). Piaget investigated the *statics of development* (Shayer 2003 p.473). This method required that the child be described in detail during the task. Piaget's method attempted to decontextualise the problem so that it provided information about the reasoning abilities of the child without any of the normal environmental stimuli, including conversation. Indeed the tasks were designed so that they were not in any way similar to those that the child had experienced before.

Rogoff (1990) notes that Piaget made the assumption *that children's cognitive activities are general across problems, requiring no consideration of the specifics of a problem* (Rogoff 1990 p.5), this could explain why Piaget did not provide satisfactory answers to why some children could not solve all of the problems that he assigned to one developmental stage. This attempted decontextualisation in his methods and assumptions about the generalisability of thinking skills may have caused Piaget problems in that it meant that he overlooked in his experiments the effects of others in learning situations (and the context of problems) although he made reference, without evidence, that peers and adults would have an effect upon the child's ability to solve problems.

Piaget talked about the cognitive conflict in collaborative situations taking the form of:

> *the working out of differences of opinion by coming to understand the other's perspective and by logically comparing the value of the two perspectives* (Rogoff 1990 p.141)

This was considered to occur in adolescence when peers of equal status worked together. Piaget placed little emphasis on adult-child relationships and their ability to generate cognitive conflict because of the differences in terms of power and status between the adult and the child. There has been evidence to suggest that equal status may facilitate balanced discussion and bring about cognitive progress in logic problems (Rogoff 1990 p.174). It is important to note, that while Piaget did consider the importance of *a common frame of reference, or intersubjectivity*[4] (Rogoff 1990 p.140), in bringing about cognitive conflict he saw the child working through this conflict as an individual; that is using the cognitive conflict to construct conceptual knowledge for them.

Piaget himself recognised that there may be social aspects to learning:

> *one cannot speak of the child without asking whether logic is a social thing and in what sense. I have been bothered by this question; I have sought to put it aside; it has always returned* (Piaget 1977 in Rogoff 1990 p.34)

Rogoff adds her thoughts by noting that if we are to understand how individuals interact in a social world it becomes necessary to accept that meaning is *more than a construction by individuals* (Rogoff 1990 p.150) and therefore I move on to show that to properly understand the nature of talk in small groups in science we need to examine a social constructivist and socio-cultural perspective of learning.

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[4] Intersubjectivity being Rogoff's term and defined as the *mutual understanding achieved between people in communication p.67*

Writers in science education, such as Driver et al (1994), have reviewed their own position on how learning in science takes place. Learning in science is now viewed, by Driver, as taking place in a scientific community in the classroom, where it is both an individual and a social process:

> *By participating in the discursive activities of science lessons, learners are socialized into the ways of knowing and practices of school science.* (Driver et al 1994 p.11)

Learning science means being introduced to scientific ways of thinking and being initiated into this scientific community. Both interaction with the environment through practical activity and talking through ideas with peers are important. Central to Driver et al's (1994) views are that children learn through '*discourse in the context of relevant tasks*' (Driver 1994 p.9) and through both of these, students become enculturated into the scientific community in the classroom. This view of science education is based in social constructivist perspectives with aspects of socio-cultural theory. Social constructivism is now discussed in more depth.

Vygotsky developed the social constructivist approach to learning. Writers, such as Mercer (2000), note that Vygotsky made interesting claims about the relationship between language and thought and the individual and society. Vygotsky believed that psychologists should investigate the r*elationships between thought, action, communication and culture* (Mercer 2000 p.10). One fundamental difference between this view and that of *Piagetian constructivism* is that Vygotsky also supported the view that:

> *The child's logic develops only with the increasing socialisation of the child's speech and all of the child's experience.* (Vygotsky 1991 p. 36)

For Vygotsky, a child's ability to reason cannot be considered without the social context within which it takes place. Roth (1999) argues that:

> *Vygotsky's (1978) view of learning . . .regards individual cognitive development as subject to a dialectical interplay between nature and history, biology and culture, the lone intellect and society.* (Roth 1999 p.10)

Here the development of the child's ability to think cannot be considered in isolation from society, affected by its history and culture. Indeed as Rogoff (1990) argues, for Vygotsky, the smallest unit that can be examined must be the individual participating in society. Rogoff describes Vygotsky's theory as *activity theory*; this is because Vygotsky studied dynamic situations where adults and children worked together to solve problems. Vygotsky focuses on the *social basis of mind* (Rogoff 1990 p.140). In Vygotsky's view *mind* is located in society because it is only through interactions with society that it is changed. Next, I will describe the society that Vygotsky felt ideal for promoting learning.

As noted already for Vygotsky the child is always a social being. Roth (1999) also supports a view that children first have to become functioning members of society before they can become themselves. That is:

> *. . . children first have to learn the ways how to make sense of others and construct knowledge which allows them to organise and relate self to circumstances.* (Roth 1999 p.10)

It is through their participation in cultural activities, solving problems with more experienced members of society, that children access more mature ways of problem solving. Their skills are developed by the child becoming more adept at using culturally given tools such as language. Rogoff notes that the tools have social roots and their use is governed by social interactions. For social constructivists, the child works with a more experienced or competent member of society to support cognitive development. In an ideal partnership one partner has to be more knowledgeable, that is in skills and understanding, but not more powerful.

Roth notes that the key to cognitive development for social constructivists is:

> *novices develop cognitive skills, that is they become fully fledged members, by participating in joint activities with more knowledgeable others* (Roth 1999 p. 11)

Rogoff goes further to say that these *shared cognitive processes* are then internalised by the child.

From a Vygotskian perspective, *intersubjectivity* (Rogoff 1990) is when *joint problem solving occurs between partners* (Rogoff 1990 p.140), that is between two people in a dyadic relationship. This joint problem solving is seen as embedded in society and is mediated by the culturally given tool of language.

How is it then that children go about appropriating this language? Social constructivists see this happening when the more and less knowledgeable work together. I now move on to discuss Vygotsky's view on the way in which this relationship, between the more and less knowledgeable, might work in cognitive development.

Vygotsky supports the view that language and communication structures are vital to learning and that understanding is constructed first in the community before it is internalised by the individual:

> *any function in the child's cultural development appears on the same stage twice, on two planes, first on the social plane and then on the psychological, first among people as an intermental category and then within the child as an intramental category* (Vygotsky 1991 p.40)

Mercer (2000) provides evidence to support this view where he investigated children, carrying out Raven's tests[5] on individuals who had been working in groups. Some of the groups had been using more *exploratory talk* and these individuals were found to reason more effectively. By increasing the *intermental* experience of these children it seems that *intramental* development may follow; a point of key importance for this research that seeks to investigate small groups and the development of *exploratory talk.*

One key question for social constructivists is at what point does the knowledge transfer from being cultural knowledge to being individual knowledge. Vygotsky describes this as being the *zone of proximal development.* Vygotsky's work demonstrated that children could reason to a greater extent if mediated by an adult. Vygotsky supported a view that good teaching should challenge the child above their current level (that is their unaided level of reasoning) and fall within the *zone of proximal development.* This zone extends to where the child's individual problem solving capabilities are improved by working collaboratively with a more knowledgeable other. The expert acts as a *scaffold* to enable learning to be further developed. In schools the experts could be more knowledgeable peers as Cole (1985) explains and:

> *extends the notion of the ZPD in such a way that it becomes ' the structure of joint activity in any context where there are participants who exercise differential responsibilities by virtue of differential expertise* (Cole in Roth 1999 p.11)

This is directly relevant to small group work in the science classroom as peers can act as *scaffolds* for each other. Roth (1999) notes the importance of collaborative learning in schools as a way scaffolding learning:

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[5] A type of reasoning test.

> *Here lies the strength of collaborative learning yet to be utilized in schools. Students can distribute the responsibilities of tasks so that the whole process does not fall on any one individual. In this, they momentarily develop differential expertise which allows students in peer groups to scaffold their abilities to more complex achievement than any one individual would have been able to accomplish.* (Roth 1999 p.11)

This study seeks to examine the nature of peer groups working together in the science classroom and whether this *differential expertise* is evident in practice and contributing to the students learning through their talk or the social roles they adopt. This collaborative group work has similarities with Shayer's idea of group work where students, by witnessing conceptual understanding in their peers can internalise it for themselves. He goes on to say *it would be meaningful to postulate a collective ZPD from which each child can draw as from a collective pool (Shayer 2003 p.471).* Here the problems of estimating the ZPD for each individual child could cause problems, realistically how could teachers go about this? For social constructivists good group work needs peers with overlapping ZPD's to be working together. That is, peers of similar ability, but with at least one peer who can act as a *more knowledgeable other.*

Moving on from social constructivism takes us on to a socio-cultural perspective of learning where the individual's goal is to make a contribution to the community to which she/he belongs. Shayer (2003) who views the role of group work and discussion as a benefit for the individual and their learning, would reject a socio-cultural perspective on the grounds that learning takes place first and foremost within the community and it is only after this that the individual internalises these new ideas for her/himself; for Shayer (2003) learning remains an individual, not a community, activity.

From a socio-cultural perspective it is not only learning through interactions with others that is important, but also the activity that the group are working on together. The activity must be rooted in the culture of the group and be *authentic*, in that it is valued by the adults in the community. Mercer uses the work of Rogoff to define a socio-cultural perspective where the view taken is that:

> *children are inducted into the intellectual life of their community by means of 'guided participation'* (Mercer 2000 p.133)

I now go on to explore the nature of this socio-cultural perspective and look at what it can offer to an understanding of group work in the science classroom.

Socio-cultural perspectives of learning consider the situatedness of the learning occurring during an activity. *Situated cognition* recognises the importance of the context within which thinking occurs. For Scribner (1986 in Roth 1999) there is a *situatedness of all knowing*. The studies of Scribner looked at the problem solving strategies used by people in different contexts, these problem solving skills were found to be context dependent and Scribner describes this phenomenon as *mind in action*; the thinking involved in everyday situations. This is practical thinking determining the necessary action needed to successfully complete an everyday activity, including all of the considerations of the situation. For example, in the classroom, the successful route to solving a problem will include the learner engaging with the practical equipment and working with others; with the social implications of this, for example groups dynamics, social roles and the knowledge that the other learners bring to this new situation. The many aspects of the context that learning is taking place within will need to be considered in this study, for example, the activity itself, practical equipment and the social aspects of the group work. From a socio-cultural perspective learning cannot be considered separately from the context within which it is

taking place. Lave (1993) provides us with a definition of exactly what the term context may mean:

> *Meaning is not created through individual intentions; it is mutually constituted in relations between activity systems and persons acting, and has a relational character. Context may be seen as the historically constituted concrete relations within and between situations.* (Lave 1993 p.18)

Context here is seen to include, the individuals and activity, acting within situations with their roots in the history of the culture, by virtue of the fact that cultural tools such as language are used to determine meaning. From a socio-cultural perspective, learning occurs when individuals take part in the activities of their community (Rogoff 1994). This taking part means that a *participation perspective* is adopted. Sfard (1998) describes features of this perspective where the goal of learning is seen to be for the purposes of building the community. Individuals are motivated to learn so that they can become full members of the community to which they belong, they do this by acting as an *apprentice* (Rogoff 1995) or as a *legitimate peripheral participant* (Lave and Wenger 1991), where they learn from the more established members of the community. In the case of my study, the teacher is a more established member of the school and the scientific community. By knowing more, the individual will participate to a greater extent in the communication within the community and may feel a greater sense of belonging. For this to be possible then the community must be able to communicate effectively during activity. Here Rogoff's (1990) idea of intersubjectivity is of central importance. Intersubjectivity is:

> *shared understanding based on a common understanding of attention and some shared presuppositions that form the ground for communication* (Rogoff 1990 p.71)

The participants must possess a common understanding of the context of the activity and enough shared language so that they can communicate to solve the problems collectively. It is not only language that is important here, but also, the establishment of shared space, objects and cognition (McCormick 2004), a further development of Rogoff's (1990) *intersubjectivity*. Sharing of space, language, objects and cognitive resources is needed if groups are to develop an *intersubjective perspective*. For the purposes of this study, this is an area of the classroom in which to work and sufficient equipment with which to carry out the task and the group working together in such a way that they open their minds to the possibility of sharing their cognitive resources by the working relationships evident in their community (This community being the context within which the learning is taking place).

I go on now to explore how learning may occur in the community from a socio-cultural perspective, exploring first the learner as a *legitimate peripheral participant* in a *community of practice* (Lave and Wenger 1991). Lave and Wenger describe this *legitimate peripheral participation* as the way in which new people join in the practice of the community to enable them to become full members. At first they are seen to observe the practice of the community from a position at the edges and then as they learn from the more established members, gradually they will start to take part in the community activities and belong to the community in a greater sense. The individual will develop in their skills and knowledgeability and the communities of practice themselves will be transformed by this. Learning is generated by the working practice of the community. Lave and Wenger define a *community of practice* as:

> *a set of relations among persons, activity and world, over time and in relation with other tangential and overlapping communities of practice* (Lave and Wenger 1991 p. 98)

Communities of practice, provide situated opportunities for new practice to be developed and in doing this develop their own curriculum for learning

specific to their needs. In schools development of communities of this kind is not seen as an objective for learning but as a necessary condition for effective learning to take place. Lave and Wenger note that in a community *circulation of knowledge among peers . . .is possible, it spreads exceedingly rapidly and effectively* (Lave & Wenger 1991 p. 93).

Rogoff (1995) goes further to describe how the individuals may *appropriate* the skills developed in the community to bring about their own cognitive development. She views cognitive development as *participatory appropriation through guided participation in a system of apprenticeship* (Rogoff 1995 p.157), where individuals move from the peripheries of the community to become managers of community activity. The role of apprenticeship, leads to individuals becoming more responsible participants in the community. Guided participation is the *interpersonal plane of sociocultural analysis* (Rogoff 1995 p.146) where the participants are involved in shared activity, this does not have to be a symmetrical relationship, and observers or quiet participants are viewed to be taking part. Central to this is working together to co-ordinate effort and communicate to search for common ground. It is this, *interpersonal plane* of *guided participation,* that is of interest to this study, looking at whether, as Rogoff (1990) and Hennessy and Murphy (1999) note peers can act as *guides* when they work together in the science classroom. For this to take place effectively then the *guides* have to have differences in their understanding. Here, it will also be explored if this guidance takes the role of *scaffolding,* where the more knowledgeable lead the less knowledgeable to greater depths of understanding. *Participatory appropriation* is the individual plane of socio-cultural activity defined as *where the person changes through involvement with the situation at hand and leads to them being transformed* (Rogoff 1995 p.153). The individual can be seen to appropriate some of the skills of the community for themselves to enable them to take part in further similar activities. Hence both the individual and the community are transformed.

Rogoff describes these as *communities of learners (1994)*, where children learn when they collaborate with other children and with adults during activity. In a *community of learners* that is made up of peers, for cognitive development to occur, this shared problem solving must be intersubjective where *social interdependence* (Rogoff 1990 p.176) can be observed. That is, the peers work together to solve a problem collectively; this working together must involve them in sharing their cognitive resources (their ideas about the issues they are discussing). Learning, as Rogoff (1995) notes focuses *on how people participate in sociocultural activity and how they change their participation demystifies the process of learning and development* (Rogoff 1995 p. 159). I go on to talk about how students might do this in the science classroom, and define collaborative learning, also exploring the talk that may be witnessed, if students work as communities of scientists in the science classroom.

Rogoff does note that the activities must have *purposes connected explicitly with the history and current practices of the community* (Rogoff 1994 p.211). In schools meaningful activities are needed that reflect the values and skills of adults. This point developed by McCormick (2004) in his work in the Design and Technology classroom where he argues that work in schools should be:

> *coherent, meaningful and purposeful within a social framework that is within the ordinary practices of the culture of technological activity* (McCormick 2004 p.164)

Roth (1999) also makes reference to this as important in the science classroom:

> *situated learning emphasizes learning through the engagement in authentic activities. Authentic here means that the activities in which learners engage have a large degree of resemblance with the activities in which core*

> *members of the community actually engage* (Roth 1999 p.17)

In the science classroom, the activities must attempt to reflect those valued by *real* scientists; Roth describes several ways in which this can be achieved. The features of this being: the problems are ill defined, uncertainties are experienced, the children engage in learning at their level, they work as a community and that community contains more knowledgeable others from who they can draw expertise (Roth 1999 p.17). Authenticity is an important factor to take into account when considering the tasks that the students are set in the classroom. For the purposes of this study the authenticity of the tasks will be examined (Chapter 3).

A socio-cultural perspective allows a fuller reflection upon the groups in this research because it not only takes into account the practical activity (interaction with the environment in Piagetian constructivism) and relationships between learners (talk and scaffolding in social constructivism) but allows all of these factors to be considered together to look at the resulting community as it develops.

Defining collaborative group work and the kinds of talk that take place in the classroom.

It is important at the beginning of this discussion to define the nature of group work in the classroom. Several authors have noted that many teachers disagree about what group work and discussion involve (Kletzien and Baloche (1994), Blatchford and Baines (2002). Kletzien and Baloche (1994) describe discussion as a student-led meaning making activity where there is an open-exchange of ideas and where the students ask questions (Kletzien and Baloche 1994 p.541). Blatchford and Baines go further to say that what may be observed in the classroom are the students working, in a team, on a variety of different tasks but they are all involved in discussion where no one student's view is more right than any of the others. When working in small groups the students have ownership of their learning; that

is if they are able to define their own roles within the discussion. They may also be involved in *collaborative* group work, the goal of which is to develop joint meaning. Hennessy and Murphy (1999) provide us with a socio-cultural definition of collaboration:

> *pupils actively working together to produce a single outcome, talking and sharing their cognitive resources to establish joint goals and referents, to make joint decisions, to solve emerging problems, to construct and modify solutions and evaluate the outcomes through dialogue and action* (Hennessy and Murphy 1999 p.1)

This is the definition of collaborative group work for the purposes of this research.

From the discussion of the learning theories above, two purposes for peer collaboration can be identified; firstly from a cognitive constructivist point of view, the role of collaboration is to generate and resolve cognitive conflict. From a social constructivist and socio-cultural point of view the role of collaboration is to provide opportunities for joint creation of knowledge. The theoretical viewpoint taken in this study is that collaboration is used to support joint thinking, or as Mercer (2000) describes this *interthinking*; this joint thinking has been defined by Rogoff as *intersubjectivity* as discussed earlier. Where we use language for *thinking together, for collectively making sense of experience and solving problems* (Mercer 2000 p.1) and in the development of scientific skills; the view of learning taken by Mercer is a socio-cultural perspective. Roth (1995), also adopting a socio-cultural perspective, notes that the results of collaboration can be a revelation to the groups working together themselves (Roth 1995 p.87); that is talking together, without an agenda for the discussion, means that they have free access to explore each others ideas.

Several points are important if collaboration is to be successful in the classroom in bringing about *interthinking* (if the groups are to develop an *intersubjective perspective* (Rogoff 1990)). The students need to learn to participate and this is seen as fundamental in learning (McCormick (2004) and Hennessy and Murphy (1999). A supportive environment is needed if collaborative problem solving is to take place (Hennessey and Murphy 1999). The students also need to establish *common knowledge* (Mercer 2000), this is the students' joint frame of reference, (Mercer's definition of an aspect of Rogoff's *intersubjectivity),* and is vital if they are to be able to work collaboratively in their small groups. This *common knowledge* exists when the students have experienced the same practical experience of teaching input in the classroom and at the outset of the activity have:

> *a basic shared understanding of the main topic and the purpose of their talk, and so could create a shared frame of reference for their activity and make sense of what was said* (Mercer 2000 p.50)

The development of intersubjectivity, between the students, in their small groups will be helped if *common knowledge* exists.

Mercer (2000) notes three kinds of *common knowledge*:

- Firstly, the *joint experience* the students have just had.
- Secondly, if there are similarities with previous work there may be the opportunities for *collective remembering* (Mercer 2000 p.50).
- Finally, if (as the students in this study) they have worked together previously in their groups they will also have a history of *joint activity* (Mercer 2000 p.50) where previous shared activity and personal relationships will also have a role in the small group work.

These kinds of common knowledge will be used for analysing the data presented in this research to see if the groups do show evidence that *intersubjectivity* is developing between them and how this affects their

group talk. This is important to establish if *communities of learners* (Rogoff 1994) have developed in this classroom.

Roth and Lucas (1997) have also identified this lack of *common knowledge* as a problem when individuals communicate with each other. They note often words are left unspoken because they are assumed to be *commonsense*. They state:

> *Talk presupposes a lot of stage setting and unquestioned mundane commonsense assumptions that are not evoked because they go without saying but which function as the background to all our utterances.* (Roth & Lucas p.147)

Whether the students develop this *commonsense*, through evidence that they use their common knowledge in their talk, will need to be considered. Solomon (1992) found that familiarity with the technical terms needed led to greater success in discussion work. This knowledge of technical terms would help the students to develop *common knowledge*. This issue would be addressed during the *concrete preparation* phase of a lesson following the CASE pedagogy. This research also supports Hand, Treagust and Vance's (1997) work where there is a tension between the students using their *own words* or the *technical* terms. Students, when they are using their own words will be able to quickly develop *exploratory talk (Mercer 2000)* but eventually will need to use scientific terms to fully express their understanding of scientific ideas. This issue will need to be considered in this study, when the students are engaged in *exploratory talk*; are they using scientific terms and what impact does this have on their learning?

Investigating collaboration from a socio-cultural perspective Barnes and Todd (1977), in their book *Communication and Learning in small groups*, have observed several interesting features of classroom discussion. These features can be used as an indication that collaborative group work is taking place; this is important in the analysis of the classroom talk in this study.

The students, observed by Barnes and Todd (1977), have been engaged in adding value to the comment of another by qualifying it, accepting the qualification of others, asking for exemplification of points, giving examples, using evidence to challenge the views of others and changing their ideas depending on the group discussion. These students, described by Barnes and Todd (1977), are exhibiting collaborative group work as it may be observed in the classroom and as it is defined for the purposes of this study. Other indicators of collaboration during the talk in small groups have been:

> *obtaining information from others*
> *completing unfinished utterances*
> *encouraging others to contribute*
> *inviting others to contribute*
> *repeating with modifications*
> *supporting another's assertion with evidence*
> (Barnes & Todd 1977 p.27)

This provides further examples of the types of collaborative discussion as they may be observed in the classroom. Roth (1995) also supports this view, noting that when working collaboratively in the science classroom, students support each other's ideas by repeating them and give each other positive verbal feedback using terms like *yea* and *ok* (Roth 1995 p.80). He also notes that when working collaboratively students can use short utterances and complete each others sentences (Roth 1995 p.87). These ideas will be used in the analysis of the data in this study to identify collaborative group work.

In small group discussion work with teenagers in the classroom (of particular relevance to this study) Barnes and Todd have noted the following four *collaborative moves;* these are *initiating, eliciting, extending* and *qualifying.* All of these help the group to discuss collaboratively together. *Initiating,* is where a new topic is introduced starting with phrases such as '*I think'* this allows others in the group to comment on the thoughts voiced.

Eliciting, this is where pupils invite another member of the group to continue what they were saying, to expand on a comment they have made, they can be requests for support or for the opinion of others. *Extending,* is where the group build on an idea that one of them has had. *Qualifying,* is where extension occurs of the thoughts that one member of the group has voiced. These are important occurrences in small group work as:

> *These moves are mutually supportive: by taking the trouble to elicit an opinion from someone else, or by utilising what has been said by extending it further, the group members ascribe meaningfulness to one another's attempts to make sense of the world.* (Barnes & Todd 1977 p. 36)

These collaborative moves will be used to analyse the data presented in this study. This will allow a full description of the group work to be provided and to assess whether the groups are developing in collaboration or not.

If an individual in the group summarises the group talk, as a way of evaluating group thought; this can threaten collaboration as Barnes and Todd warn,

> *A person who offers a summary is often for the moment detaching himself from the give and take of the group: such 'chairman's moves' may be potentially threatening to a group's sense of a common purpose, since the temporary chairman may be seen to be claiming authority.* (Barnes & Todd 1977 p. 67)

Making a chairman's move could cause social problems in the group, although summarising group thought may help the group evaluate where they are up to in the task and could be necessary at some points for learning to take place. How the individual that makes the *chairman's move,* manages this, could make the difference between it encouraging

collaboration or not. What can be observed is that the individuals need to be concerned with expressing their ideas in a way that other members of the group understand, linking back to *common knowledge (Mercer 2000)*. For good collaborative talk, occasionally an individual has to summarise group thought and how they go about this can make the difference between whether it is successful or not in maintaining a collaborative group atmosphere.

I move on now, to discuss the types of talk that have been identified by other authors, when students talk together in the classroom. These are important for this study in helping to provide a full description of the talk and to give an insight into its purpose in terms of the groups' learning. These types of talk can be used to identify whether a collaborative group has been developed. This research seeks to examine these types of talk as they occur in the science classroom to explore the impact they have on *interthinking*. Mercer (1996) described two types of talk, *critical knowledge building* and *uncritical knowledge sharing*. When students are engaged in *uncritical knowledge sharing* characteristically they are not in conflict with each other and have the same level of knowledge that accumulates as the conversation continues. During *critical knowledge building* the students challenge each other's ideas and jointly consider these to develop a shared decision. The students are committed to solving problems together and may be involved in *interthinking*. Mercer (2000) provides further explanation of these ideas and puts forward further descriptions of talk. If students in the classroom are engaged in collaborative discussion to bring about *interthinking* then ideally they will be engaged in *exploratory talk*. This definition provided by Mercer (2000), is based on the original idea of Barnes and Todd (1977):

Exploratory talk . . .

is that in which partners engage critically but constructively with each other's ideas. Relevant information is offered for joint consideration. Proposals may be challenged and counter-challenged, but if so

> *reasons are given and alternatives are offered. Agreement is sought as a basis for joint progress. Knowledge is made publicly accountable and reasoning is visible in the talk.*
> (Mercer 2000 p.98)

This *exploratory talk* has similarities with *critical knowledge building*. The signals in group discussion that their talk is becoming exploratory are that the following terms may be used; *because, if, why, I think* (Mercer 2000). Mercer notes that what is important here is that all children understand the social ground rules for talk (Mercer 2000). Mercer (2000) lists these as:

OUR TALKING RULES

**We share our ideas and listen to each other*

**We talk one at a time*

**We respect each other's opinions*

**We give reasons to explain our ideas*

**If we disagree we ask 'why'?*

**We try to agree in the end (Mercer 2000 p.162)*

Wegerif (2002) has found that some children have an innate awareness of these rules. For Mercer the ideal situation for developing *exploratory talk* is if these rules are taught and agreed by the students. The students in this study were not taught these and whether this innate awareness is evident will be explored to look at the impact this has on group work.

Two further types of talk are identified by Mercer, *cumulative talk* that is uncritical, non-competitive and constructive. The final type of talk is *disputational talk* where the individuals seek to maintain their own identity and in doing so will keep reasserting their own point of view and not listen to the opinions of others. Other individuals are viewed as a threat and the collaboration becomes confrontational (Mercer 2000). These more recent and refined descriptions of *exploratory, cumulative* and *disputational* talk

will be used to analyse the group talk in this project[6] with a view to providing an insight into how the groups use talk to learn in science.

Two further categories of talk will be used to analyse the data in this study; Arvaja et al (2002) researched collaborative learning in the science classroom. Two categories of talk were identified as being irrelevant in that they did not contribute to the knowledge construction of the students; *technical talk* where the students discussed issues such as how to work on the computer (in this study the students could be organising themselves to carry out the practical task) and *off task talk* (this could include talk of a social nature) where the students were not talking directly about the task. These categories will be used to analyse the talk that takes place when the students, in their small groups, are not talking about their ideas in science, in order for a full talk profile to be developed for each group. This is important in providing full descriptions of the talk taking place in each group.

Social talk, although it can be categorised as *off task* talk, was found quoted by Barnes and Todd (1977) to have an important function in the group work. They report that research into discussion groups carried out by the University of Keele found that for maximum cohesiveness then it is acceptable for a group to spend 20 - 25% of time engaged in talk of a social nature. This finding will have implications for the analysis of data in this research. Social talk can be considered to be useful in nature as it is thought to bring about group cohesiveness, is the social talk carried out by these groups bringing about group cohesiveness and contributing to learning?

The categories of talk identified here will be used to explore the data collected in this study; *exploratory, cumulative, disputational (Mercer 2000), technical* and *off task (Arvaja et al 2002).*

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[6] Alexopoulou & Driver (1996) also identified two categories of talk *progressive,* similar to Mercer (2000) *exploratory* and *cumulative* and *regressive,* similar to Mercer's *disputational.* Mercer's more detailed categories are used for the purposes of this study.

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What is needed for collaborative group work to be fostered in the classroom?

This study seeks to describe group work as it may occur in the science classroom. It is important to consider, if group work of a collaborative nature is found, the reasons why this may have occurred and this is essential if these findings and this literature review are to be used to provide advice for practitioners in the classroom. Hennessy and Murphy (2001) have found that a supportive environment to foster good collaborative talk may be developed if the following factors are taken into account in the teacher's planning of the activity:

- The teacher themselves must be committed and understand why collaborative talk is important.
- The task must be purposeful and authentic.
- The students must be able to lead and participate in it and there needs to be opportunities for thinking to be shared.
- Enough time must be allocated to the small group work.
- The students should be able to scaffold each others' ideas by discussing and reflecting upon them.
- They need to be able to discuss decisions and develop a group ethos whereby they learn from feedback.

From the perspective of the students they need a *shared frame of reference* or *common knowledge* (Mercer 2000) as noted earlier, because they have to understand why it is important that they participate in the activity and they have to possess the skills needed (social and cognitive) to take part in shared decision making.

It is important that the group work time in this project is planned to take account of the above advice. These issues will be accounted for in Chapter 3.

Other research has also provided advice on how to design small group work in the classroom and other factors that can affect it. I go on now, to examine the factors that are of interest to this research.

- The effect of task on collaborative group work.

For groups to develop in collaboration, the nature of the task that they are engaged in has been found to be important. This can have an influence on the levels of work-related talk, a point noted by both Barnes and Todd (1977) and Hennessy and Murphy (1999) who said that *collaboration will not occur unless children consider the task worthwhile to solve together (p.17)*. The collaborators need to talk about the task and *engage with task cues to establish. . . a shared reference concerning the nature of the specific task, its purpose, and a notion of a global solution or outcome* (Hennessy and Murphy 1999 p.5). From the research of Hennessy and Murphy (2001) the type of task that was found to be successful at developing talk and led to an increase in understanding, was where students were involved in the development of a hypothesis. The *interthinking* involved when the group are developing a hypothesis may lend itself well to using the *collaborative moves* described above. The categories of talk described above will be used to examine the tasks in this study, in order to describe if these tasks do have an impact, in this classroom, on the talk that develops.

- The effect of group size on collaborative group work.

Group size can also impact upon whether good collaborative talk is developed. Alexopoulou and Driver (1996) found that when students worked in pairs it was noted that the way the pupils discussed was related to the following factors: the pupils' interpretation of the task, the pupils' perception of their own ability compared with their peer and whether a competitive or collaborative approach was adopted. In fours, conflict of an interpersonal nature is more easily avoided, groups of four therefore being a more successful option. It was claimed that this was the case because in fours it was accepted that individuals might have a different viewpoint. On occasion it was observed that some pupils did not make a contribution to

group discussion because of social constraints. Alexopoulou and Driver (1996) advise that teachers:

> *move towards fours rather than pairs for group discussion in science, as the social interaction in fours seem to function more effectively* (Alexopoulou & Driver 1996 p.1112)

They also note the importance of students being able to work in groups chosen by them and claim that it is of fundamental importance that the pupils want to work together. In my study, students worked in the groups of four that they had chosen.

- The effect of students' abilities on collaborative group work.

The ability of the students can also be important, Hennessy and Murphy (1999) discuss the work of Light et al (1994) who have found that students ideally should be grouped with children of similar abilities, as this seems to limit any one individual taking over the group. This has similarities with Piaget's thoughts about the ideal relationships to bring about talk generating *cognitive conflict*. Although this is at odds with social constructivist and socio-cultural views where a more knowledgeable other is needed for *scaffolding* or *guided participation* to take place. What is probably needed is a group made up of individuals with overlapping *zones of proximal development* so that they can scaffold each others ideas' and develop their group understanding of science. This would mean that they could share their *cognitive resources* developing their group *intersubjectivity* because they possess a joint frame of reference within which they are all capable of taking part. In my study, the groups are made up of students of similar ability, but all of the students would be considered to be above average; their attainment in the Key Stage 2 National Curriculum statutory tests was above the national average for their age. This data was used to group the students into this form group, at this early stage in the year I had little data from my own assessments but what I had supported the view from the

National Curriculum tests that these students were of above average ability. The students had organised themselves into groups and two groups were chosen by me, at random, from all the groups in the class to be described in this study. The students in my study should have been able to cope well with the scientific concepts developed during this excerpt of their science lessons. These groups should not have found these scientific ideas difficult. What does need to be considered in the data analysis is whether a *more knowledgeable other* can be identified and how this affects the group talk.

- Issues related to the personal characteristics of the individuals in small groups and the effect on collaborative group work.

Issues are raised about the fact that the personalities of the children in a group can have an impact upon learning (Hennessy and Murphy 1999). Their personalities will influence the social roles they adopt, discussed later in this review.

- Humour and its role in collaboration.

Humour can also play an important role in collaboration. Groups, sometimes put gentle pressure on one of the group to conform, using humour, and *jokes* are important if groups are to cope with strong negative feelings such as anger. Supportive behaviours are also noted when questions are asked of a group member who has been quiet for some time, using statements that show agreement, using names, using phrases to soften disagreement such as *'I suppose you've got a point'* and praising the opinions of others.

Small groups and social roles in science.

I go on now, to identify the types of small groups that exist when people work together. Argyle (1969), in his study of small social groups has found that small groups can be defined by the patterns of interactions that go on within them. In his studies he has described the patterns of interactions that go on in a number of different contexts: family groups, adolescent groups, work groups, committees/problem-solving groups and therapy groups. Of

interest to this study are adolescent groups and work groups. Most of the previous research in this field was carried out under controlled conditions in a laboratory and Argyle noted the need for detailed studies of small groups to be carried out in the field (the type of research carried out in this study) as discussed in Chapter 3.

Argyle discusses three aspects of groups that are important considerations when small groups are being observed, they are important because they provide the observer with an indication of how the social aspects of the group are developing, it is important if these social aspects are affecting the group talk. In this study it is important to look at whether these social processes are affecting the group talk and therefore the learning that is taking place. Argyle calls these the *norms* of behaviour; this is how the group responds to the task and solves any interpersonal problems. Leadership and power issues need to be considered, who has social influence in the group and also liking and disliking between members of the group (the social roles and relationships). How individuals in the group communicate and interact with each other also needs to be observed (the nature of the collaboration). Argyle provides evidence that a group is developing in *cohesiveness* when they will increase the use of the term *we* and use this more than *I*. Thomas (1957) found that division of labour in a group was needed for success saying that,

> *complementary roles a cooperative relation was established between them: there was greater cohesiveness, greater effort, more work and a greater feeling of responsibility.* (Argyle1969 p. 222)

This division of labour takes the form of the students adopting different social roles may also allow students to create a situation of differential expertise so that they can *scaffold* each other's ideas. Later in the chapter I go on to look at social roles and how this may be identified in practice.

I go on now, to look at the key features of Argyle's (1969) *adolescent* and *work* groups. His adolescent group demonstrate the following key features: attachments to friends are strong, conversation is mainly about peers, parents, feelings and social lives (that is *off task talk Arvaja 2002)*, leaders can rotate as different tasks are approached, the best person at each activity is the leader (similarities with collective ZPD and peer group interactions described by Cole 1985 earlier in the chapter). From the discussion related to categories of talk, these groups could demonstrate increased levels of *off task talk* (Arvaja 2002) and low levels of *exploratory talk* (Mercer 2000). Schumck and Lohman (1965) found that the following behaviours might be found in adolescent groups where they:

> *often engage in infantile behaviour and pranks, while giggling and laughing hilariously; and are encouraged to feel silly together, and to withhold evaluation from such experiences.* (Schmuck & Lohman 1965 quoted in Argyle 1969 p. 247)

This type of group could have difficulty using collaborative talk as a strategy for learning in the classroom as they may be involved in *off task talk* of the nature described above.

Argyle's work groups are different from adolescent groups in that their role is to carry out a task. In my study, the students are in groups to carry out a task. It is noted that group cohesiveness is an important feature although it is not always the case that these groups do more work; they may stop the activity in order that they can talk socially. Here *cumulative talk* and *exploratory talk (Mercer 2000)* may be evident. Talking socially may serve the purpose of building group cohesiveness and aid further group work (Barnes and Todd 1977). These descriptions will help to analyse the way in which the small groups in this study work together in the classroom.

The ways in which small groups organise themselves can affect whether they successfully become collaborative or not. Researchers have defined several ways in which small groups organise themselves and the types of small group that develop. Arvaja et al (2002) identified significant social groups demonstrated by students when they were working together in the science classroom. When all students did not make equal contribution to the concept building discussion this was often because of *leader dominance* where the leader in the group just passed on information to other students in the group. In this case, it was found that the students did not work in a collaborative way, they did not share their cognitive resources when working together on a shared task. Whilst it is not necessary for everybody in a group to talk to the same extent, it is important that everybody's ideas are heard. It was often found that these groups would complete the task but that not every individual in the group took part in *joint uncritical knowledge sharing*[7] talk. *Tutoring* effects were also found, where a more experienced individual in the group was able to encourage others to share their understanding. The *guide,* who demonstrated greater understanding, was able and willing to share this with others in the group in a way that allowed all members of the group to participate. This has similarities with aspects of the *interpersonal plane of sociocultural theories*; described by Rogoff (1995) as *guided participation.*

To provide a full description of how the groups work together in the science classroom, the *small social groups* in this study will be discussed and compared to groups described by Arvaja et al (2002) and Argyle (1969).

Moving on from looking at the group as a whole, I go on now to look at how the individuals may behave within the group. The social roles adopted by students when they work in their small groups in the science classroom can impact on whether as a group they can engage in good collaborative talk; talk that allows *interthinking* to take place.

[7] The category of talk used by Arvaja et al (2002).

Richmond & Striley (1996) considered learning in science to be more than a product of ideas, but brought about through the interactions of the student with both the teacher and their peers. In their research on discourse and small group interaction in the science classroom they found that *specific social roles and leadership styles developed within groups that greatly influenced the ease with which students developed scientific understanding* (Richmond & Striley 1996 p.839). In their four person groups the following social roles were found:

- leader, an able, action planner who liaised with teacher
- a competent helper
- a passive non-contributor who rarely contributed and copied
- an active non-contributor who was often off –task and disruptive.

From the features discussed above, it would appear to be unlikely, that this type of group would develop good collaborative talk. They do not appear to possess the social skills, as a group, to develop a sense of team. The passive non-contributor and active non-contributor would not take part in the type of discussion that would allow *interthinking* to occur. The imbalance in power could case problems, with every individual not being able to share their ideas with the group.

Hogan (1999), in her studies of collaborative learning in the science classroom identified eight roles that students can adopt during small group discussion. Hogan defines a role as being *consistent patterns of participation in group practices (Hogan 1999 p.861).*

Hogan describes four of these roles as supporting collaborative group work:

Promoters of reflection are those students who move the group on and force them to look collaboratively at their ideas. They also reflect back upon the teachers' guidelines as a means of refocusing the group back on the question. Students may also raise concerns about how the group are carrying out the task.

Contributors of content knowledge are the students who are a resource for their group in that they have a good conceptual knowledge of the topic. They can provide explanations for the ideas discussed in their groups.
Creative model builders are the students who generate new ideas in the group and provide ideas for further refinement.

Mediators of group interactions and ideas are the students who facilitate discussion by mediating the group through any conflicts that may occur.

Hogan describes a further four roles that inhibit group discussion of ideas:

Promoters of acrimony are students who show an open dislike for another member of the group and this distracts the whole group off task.

Promoters of distraction are students who exhibit silly behaviour and lead the group off task with this.

Promoters of simple task completion or unreflective acceptance of ideas these students will take the easiest route to complete the task and will write an answer down to a problem and accept it rather than reflect upon it.

Reticent participants in collaborative knowledge building these are the students who make very little verbal contribution to the group discussion. It could be said that these students would prefer to be working alone.

Hogan (1999) supports a view that students should not be given a role to play in group discussion but, that these roles are allowed to develop simultaneously. This research will explore whether these social roles are evident when students work together in this science classroom and whether they do impact on the collaborative group talk that may be occurring.

Leadership, as indicated above, is also an important issue when students work in small groups. For effective, collaborative group work to develop

leadership issues need to be resolved. Richmond and Striley (1996) identified three types of leader. The types of leader students were, depended upon their academic ability and social role. *Inclusive leaders* were characterised by the fact that they asked questions, opinions or comments from the group. *Persuasive leaders* presented their ideas and then tried to persuade the others to accept them; they refused to negotiate if they were challenged. *Alienating leaders* possessed strongly held beliefs and alienated themselves from the rest of the group. The type of group leader present did affect of the learning of the individuals

> *Students' access to information necessary to build these arguments and set them in a larger body of knowledge depended partly on the dynamics of the group in which they work, which in turn was determined by the style of that group's leader. Such access was not equitably distributed.*
> (Richmond & Striley 1996 p.855)

Groups with inclusive leaders were on task and saw how the knowledge constructed built into the bigger picture, those with persuasive leaders were motivated but only the leader saw the *big picture* and those with alienating leaders were off task, their learning was significantly lower.

In my view, an inclusive leader would be required for *exploratory talk (Mercer 2000)* to develop, for the group to achieve a collaborative state; this would allow all individuals to share their cognitive resources. For this *exploratory talk* to develop there may not just be one *inclusive leader* in the group but the group's leader changing, depending upon the need of the group at that time.

If leadership issues are not resolved and groups do not develop in collaboration then conflict becomes inevitable. It is also the case that it is necessary in small groups, and likely to form part of the talk observed in this study. *Cognitive conflict* is needed for learning to take place as described

by Scanlon (2000) whose research took place in the science classroom. She discusses the impact of conflict on small group discussion and notes that cognitive conflict must occur, a debate about ideas, but that the students must be able to differentiate between and arguing. Scanlon defines three types of conflict; *conceptual conflict* when the findings of an investigation contradict students preconceptions[8]. *Procedural conflict* is another type of conflict, where the students cannot agree on what to do and *social conflict* where the students argue in a way that interrupts their work. The data in this study will provide descriptions of where these types of conflict exist in the small group discussion observed and the impact that they have upon group talk. This conflict, particularly *social conflict*, may affect the groups' ability to talk in a collaborative way about their work. In a practical science lesson, *procedural conflict*, may affect their ability to work through the task and therefore produce any data to talk about.

Other factors have been found that play a role in inhibiting collaborative talk. Barnes and Todd (1977) note that controlling progress through tasks can be a more difficult process for a group if they are also involved in the manipulation of equipment, a key consideration when considering small group discussion in the science classroom and a point of concern for the purposes of this study. It is through the manipulation of equipment that *procedural conflict* (Scanlon 2000) could arise.

Barnes and Todd (1977) also make comment about conflict as it has been observed when students work in small groups. It was found to be a key inhibiting factor when it is social in nature that is when one member of the group has a more aggressive style. It can be averted by the gesture and tone of voice of the individual who challenges the view. Barnes and Todd consider that conflict will not arise in a group if its members are able to take qualification of their thoughts without assuming that it is a personal criticism. Conflict and discussion that allows the group to improve the

[8] *Roth (1995) also finding this notes that some individuals can be seen to hold on to their own ideas despite intense discussion. These students also wanted to revisit topics agreed by the rest of the group to try to change group opinion. He goes further to say that the group may never resolve this* cognitive conflict *nor is it necessary (p.92).*

social relationships can take up time and stop the students learning. It is not only important that the group work collaboratively but that this collaboration leads to learning, indicated by *exploratory talk* developing and *collaborative moves* being found in the talk. Barnes and Todd note that, *The egocentric desire to display knowledge is frequently in effective opposition to the wish to collaborate in constructing knowledge.* (Barnes & Todd 1977 p. 54) This is where individuals in the group are more interested in demonstrating their own knowledge rather than collaborating with the rest of the group to develop a joint understanding (they may be taking part in *disputational talk* Mercer 2000*)*.

Barnes and Todd (1977) summarise the factors that can lead to small groups being less effective at developing collaborative talk. Competition, conflict and aggression (also found by Scanlon 2000) and deciding who to allocate to which role (a point noted by Hogan 1999). The students can worry about whether the task is being carried out correctly and become involved in *procedural conflict (Scanlon 2000)*. The students can fail to challenge the incorrect ideas and assumptions of others or not critically evaluate their opinions (again can depend upon the social role adopted by the student Hogan 1999). They fail to make full use of the information provided for them by the teacher and panic that they will not complete the task or carry it out correctly. Here the students are distracted from using the time allocated to carry out *interthinking* and become preoccupied with the practicalities of the task (carrying out *technical talk Arvaja et al 2002)* or the social relationships within the group.

When planning group work behavioural issues will have to be considered, that is setting up the groups so that they can work together effectively (cognitively and socially) and in the introduction to the activity the teacher must ensure that the students understand the terms needed to quickly bring about *exploratory talk* and *interthinking* and are able to carry out the task effectively.

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Gender issues and their impact on small group work.

This research analyses two groups, a single sex group of four boys and a mixed sex group of two girls and two boys. In the next stage of this review I go on to explore literature that provides an insight into how gender issues may impact on small group work; in order that the data presented in my study includes an understanding of gender and its impact on the groups.

Research has provided detailed observations, from the classroom, when students work together in single sex and mixed sex groups. Firstly, students working in single sex groups are considered. When girls work together in single sex groups; Arvaja et al (2002) found that they were successful at collaborative discussion in the science classroom:

> *It became evident in the girls working that having an open communicative relationship with each other, based on friendship and prior collaboration, they were able to reach a high level of collaboration* (Arvaja et al 2002 p.174)

This point is also supported by Murphy (1998) who found single sex groups of girls appear to be highly successful. Murphy examines the evidence that girls are able to '*think strategically for each other*' (Murphy 1998 p.264). Her research also shows that girls carry out more sharing of the same task. Murphy (1998) notes that for successful collaboration, the sorts of communication skills needed are those fostered by females in society. What is required is the ability to: verbally plan, negotiate alternative suggestions, share equally in decision making and talk to allow conflict to be reconciled. In girls, these qualities may well be nurtured with the implication being that they may need to be taught to boys. For all girl groups, She (1999) found that they devoted a lot of time to talk about procedural understanding; how they carried out the investigation and the results that they obtained. The girls would also ask each other for help.

Investigating single sex boy groups, She (1999) found that they tended to ask for the help of the teacher. They were found to spend time discussing scientific concepts and the boys corrected each other's ideas to a greater extent. Matthews (2001) investigated students' attitudes to working together in small groups. He found that boys in single sex groups seemed to experience difficulties in working together. Matthews says;

> *Boys in single-sex have got worse; this could show the difficulties that boys can experience in coming to terms with social and emotional factors.* (Matthews 2001 p. 9)

The single sex group of boys in my study will be examined to see if they do have difficulties coming to terms with the social relationships in their group. Murphy (1998) found that there is also a competitive element to the boys' group work. Murphy also notes that boys tend to choose to work alone which does not allow them access to peer-peer discussion or to work in a collaborative way. Murphy concludes *boys need to be aware of the limitations gendered learning places on their potential to hear and benefit from others creative thinking* (Murphy 1998 p. 274). It would seem that boys experience difficulties when working together in single sex groups.

Moving on to consider mixed sex groups; Swann (1992) quotes the work of Rennie & Parker who found that Girls . . . behaved differently in different contexts; they tended to spend more of their time watching and listening in mixed sex groups (Swann 1992 p. 57). In mixed sex groups, boys controlled the discussion while the girls remained supportive and passive (Swann 1992p. 63). Swann and other researchers are concerned with the perceived dominance of boys when working in small groups and this remains an issue for the small group work investigated in this research. Murphy (1998) notes that in mixed sex groups;

> *Girls were observed displaying 'an ability to take on a wide range of issues in discussion' and act as facilitators to the*

boy's ideas 'being able to give them lots of support and to point out the strengths and weaknesses of their ideas'. (Murphy 1998 p. 261)

Here they are contributing to the group, but allow the boys to lead the group and dominate the discussion with the boys' ideas. Scanlon (2000) researched mixed sex groups in the science classroom finding that, in general, they were unsuccessful and this occurred because of the negative influence that conflict had on the group. Particularly of note is that, boys seem unable to distinguish between disputes because students held different ideas or views; they seemed to perceive this as arguing. This is in contrast with Murphy (1998); conflict may occur if the girls are dismissive of the boys' ideas or if the boys in the group are competitive and disagree with each other.

In mixed-sex groups, She (1999) found that boys participate less and that girls tended to read more of the information provided by the teacher. This is in contrast with the above domination of boys but it may be that the boys are working as individuals (Murphy 1998). The girls also seem to rely on the teacher more than the individuals in their group. She (1999) notes, that the social roles that the students adopted in mixed-sex groups were changeable and there was little evidence of talk about scientific concepts. The boys in these groups tended to carry out more of the practical activity, this links with the physical dominance of boys found by Swann (1992). Arvaja et al (2002) found that girls also seemed to be able to remain on task when working in mixed sex groups with boys. *Leader dominance* was noted when the students worked in mixed sex groups where one individual shared information with the group and the group were not working collaboratively. Hogan's (1999) findings were also supported in that mixed sex groups were less involved in the type of discussion that would lead to the building of knowledge. Arvaja et al (2002) summarise by noting that whether students can collaborate depends very much on the context within which the

discussion is taking place; one very significant part of this context being the other individuals in the group.

To summarise and compare the above authors, various points are of interest to note and are summarised in Table A – Appendix a.

The research discussed above provides a framework for exploring the gender issues associated with the small groups in this study. It will help to provide insights into the social relationships in the group. It will also help to compare the small groups examined in this study with single sex boy groups are mixed sex groups previously researched and so make a small contribution to the debate about gender issues and small groups.

Summarising the issues drawn from the literature needed to provide a full analysis of the data.

This review of literature has led to several ways in which the data in this study must be analysed. These are briefly listed below:

- The role of talk in the small groups and how this talk indicates that the students are learning in science.
- The type of talk that develops in the groups, examining the categories of talk; *exploratory, cumulative, disputational* (Mercer 2000), *technical, off task* (Arvaja et al 2002) and whether this talk is collaborative in nature or not.
- Do the students use their own words, or technical terms in the talk?
- Are *collaborative moves* Barnes and Todd (1977) evident in the group talk?
- Do the students show an innate awareness of the *ground rules* for exploratory talk (Mercer 2000) and what is the impact of this?
- Whether *differential expertise* is evident and demonstrated through talk or by the social roles that the students adopt.
- How are the groups participating in socio-cultural activity? Are *communities of learners* developing?

- Are the students using their *common knowledge* (Mercer 2000) as the basis for their group talk?
- The type of small social group that develops (Argyle 1969, Arvaja et al 2002).
- The social roles that the students adopt and the impact this has upon their group talk (Richmond & Striley 1996, Hogan 1999).
- The leadership found in the small group (Richmond & Striley 1996).
- Scanlon's (2000) definitions of conflict will also be used to analyse the data.
- Gender issues will also be examined as described above.

All of these issues drawn from the literature seek to address the research questions for this research project; in summary, what is the nature of the discussion carried out when students work in small groups in this science classroom?

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Chapter 3 Methodology

The main research question I am addressing in this project is; how do students work together in small groups in the science classroom? This is in terms of the language that they use; the type of talk that develops and how the group use this talk. How the groups work together, that is, the social relationships that develop, the social roles that are evident in their groups and the impact of these on the group talk. The nature of these communities, which develop in this science classroom, will be explored.

In the pilot work for this study I observed Key Stage 3 students engaged in talk, in small groups, in their science classroom. The groups that the students worked in were chosen by themselves, as in the main project. This pilot work allowed me to trial the collection of data where I identified categories of talk when the students were working in their small groups and this enabled me to describe this talk as it is found to occur when the students work together in science. From identifying these categories I went back to the literature to see what other researchers had observed. The data collected in my pilot study supported my review of the literature, in that I found that my categories were also described by others researchers and this enabled me to use these descriptions, from other authors, to analyse the data in the main study and supported my view that the data I was collecting was relevant and worthy of description. Analysing the findings from my pilot study, that is the development of categories of talk, and locating this within the work of other researchers makes my analysis of the data and any subsequent findings more valid.

It was at this stage, and during the development of these categories, that I decided to focus on describing, in detail, talk in science that I felt directly led to the development of the students' understanding of science or that talk demonstrated their understanding of science. It was talk of this sort that I was interested in, that contributing in some way to their learning. I also felt that it was important to provide a full talk profile for each group considering

all of their talk. All of the talk was categorised for each group and then I went on to describe in detail the talk that I felt demonstrated learning or understanding of scientific ideas. From the pilot study, I went on to develop activities that would support the students in talking about their own scientific ideas (described later in this chapter). During the pilot study, I observed students talking about their observations of data generated during practical activity, developing conclusions from this and talking about scientific ideas using questions set by the teacher as a prompt for their talk. The kind of talk about science that I wished to describe was limited by the activities in the scheme of work, which were modified to include opportunities for talk, but had the same learning objectives as those activities carried out by other Year 7 classes.

The *science* that the students were talking about fell into three main areas: Activity 1 provided opportunities for talk about the results of a practical investigation and how the students used their data to develop conclusions from their practical work. During Activity 2, I was again interested in how they used their data, but I also wanted to find out whether they used the scientific ideas and procedural understanding they had developed during the previous lesson. In Activities 3 and 4, the science that the students were talking about was their scientific ideas and the information they could recall about the key areas they had been studying during this topic; Activity 3 involved them in talking about one area and was open-ended and in Activity 4, the groups used prompt questions set by the teacher to review the whole topic. These activities were similar to those I had trialled in the pilot study, so I felt confident that they would provide opportunities for talk about science. The *talk about science* that this study focuses on is:

- How students talk about the data they have collected during practical work and use this to develop conclusions about their findings.
- How students use the development of scientific ideas and procedural understanding from previous lessons to support their development of conclusions in related contexts.

- How students use existing knowledge and understanding of scientific ideas to respond to open-ended and more structured activities set by the teacher.

For the other categories of talk, my aim was to provide the reader with an overview of this talk to help them to appreciate the social relationships and roles and the influences that these may have had on the groups' talk in science. For example, for disputational and social talk, I have provided the reader with an overview of this talk because it does give us an insight into how the groups work together and the other influences there may be on talk and its contribution to learning when adolescents work in small groups.

The aim of this chapter is to examine the research methodologies and methods that best allow these questions to be answered. In this chapter, I will begin by outlining the methods used by other researchers in the field to explore similar issues. I will then discuss practitioner's research and the ways I employed this kind of research in my study. This chapter also includes a discussion of the research design of the study.

Comparing and contrasting the research methodology for this study with other research in the same field.

In order to consider small groups at work, several authors have noted that it is important that research takes place in the classroom and not under laboratory conditions (Argyle 1969). Blatchford and Baines (2002) go further to say that it needs to take place in authentic classroom settings. The methodologies adopted in this study aim to collect the data in such a way, that during this snapshot into the science lessons of these students, the data collected is as realistic as possible. This is supported in two ways; firstly, by a qualitative, ethnographic approach being adopted to collect the data and secondly, because this is practitioner research, taking place within my own classroom. I go on now to examine qualitative approaches taken by other researchers and use them to justify the approach taken in this study.

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Major researchers in the field of group work and classroom talk often use qualitative research methods in their studies (Barnes & Todd 1977, Edwards & Mercer 1987) to explore children at work in the classroom. As noted by Hennessy and Murphy (1999):

> *To enhance our understanding of collaboration through discourse, we turned to the established tradition of qualitative research into classroom talk*, (Hennessy and Murphy 1999 p.18)

I go on now to explore these qualitative methodologies used by related studies to this project; the purpose of this being to provide justification for my own approach to collecting and analysing the data in this research.

Alexopoulou & Driver (1996) researched 14-15 year old students working in their own science classrooms in a Greek Secondary School. They were trying to establish the optimum number of students to work in small groups in a way that allowed *progressive discussion* to take place (discussion where scientific understanding is developed). Alexopoulou & Driver were particularly interested in how students of their age thought about everyday scientific phenomena, how they discussed these and how they helped each other to discuss unclear points. The students were introduced to the researchers by their teacher and then the researchers taught them in the classroom. The students were pre and post-tested to establish their qualitative reasoning using open-ended questions. The group discussion, as the focus of the research, was audio taped and this talk coded into two categories; talk developing conceptual understanding and talk about misconceptions. This (and the test data) helped the researchers to identify groups involved in *progressive* and *regressive discussion*. Sixteen samples were then chosen and these audio recordings coded in the following ways:

- Type of argument construction, based on the work of Barnes and Todd (1977).

- Social interaction coding, where the researchers noted whether the students were agreeing, disagreeing or asking questions.
- Social dimension, whether talk expressed support, aggression, uncertainty or confusion.

The similarities with my study are that the classroom talk is analysed in order to describe the type of talk identified and to categorise it. This uses recorded talk as the data source, an approach adopted in this study. This data was then used by Alexopoulou and Driver, to provide advice for teachers about how to set up group work in the classroom to support learning. From this then, the use of classroom talk as data is a justified way of researching small groups in the classroom, in order to provide advice for practitioners and in order to categorise talk. Features that differ from my research are that I did not use pre and post-test data and that my research is practitioner research, where I taught and researched within my own classroom.

Alexopoulou and Driver's findings supported a view that it is better for students to work in groups of four and that they self select their groups. In this study, the students were asked by the teacher to organise themselves in to groups of four and so they did choose their own groups. This point is also supported by McAllister (1995), who in her research with twelve year olds of average ability (the same age and ability as the students in this study) found that four people in each group is the ideal number and that it is important that they are happy to work together:

> *I feel it is important to allow pupils to be with friends of their choice in the initial stages of group work where the pupils are attempting to cope with a new situation*
> (McAllister 1995, p.400)

McAllister and Alexopoulou and Driver note the same findings using different research methodologies. McAllister's research is practitioner

research, as the data was collected by McAllister, as a participant observer, in her own classroom. This is an important point to note; both the research carried out by the educational researchers and by a practitioner using different methodologies, still the same findings are reported and this leads to an increased reliability in the data. The findings of research become more generalisable when they are located within the findings of other researchers in the same field, this helps to triangulate the data. Keying my findings into previous research will give them a more secure base from which to offer advice to other practitioners.

My research seeks to increase the amount of time that students talk in small groups, discussing their work in science. So it is important, as McAllister notes, that in this new situation (working in small groups), being with their friends may provide a more supportive environment. Alexopoulou and Driver also note for further research that they only looked at an hour's interaction and that it would be beneficial to look at students' interaction patterns over time, although they gave no further detail in how to go about this. This is an important issue, as changes may occur as the groups gain more experience in working together. My study looks at how the interactions change in the groups over the four activities, to see if details can be given of the changes in interactions over the time of these observations and to assess if four observations are enough to produce reliable findings on this issue.

Also researching discourse in the science classroom, Richmond and Striley (1996) were interested in the building of knowledge and how this was affected by the way in which the students talked with one another. They focussed upon;

- the setting of the talk
- the status of the students involved in it
- the fate of the ideas.

The activities they used had been designed to encourage the students to talk about their ideas and help each other; an approach adopted in this study. All the students were in mixed sex groups of four or five, with six groups being audio taped and two groups video taped during planning and interpretation phases of a scientific investigation. The researchers used a combination of field notes, (where they noted concepts that the students were struggling with and their social interactions) and audio recordings of the classroom talk. The audio recordings were transcribed and analysed using the following categories;

- who made the contribution
- the number of contributions per person
- what they said
- what they meant (intent)
- the consequences of the contribution
- the extent to which it was task related.

The data was used to look at the number and kind of contribution made by each student to determine their task engagement. The outcomes of the data were that social roles were identified in group work when students work in groups of four (discussed in Chapter 2). This approach was also adopted in this study to look at the individuals in the group and how much contribution they made to the discussion in their group as a way of determining their engagement with the task and whether their contributions to the group changed over the four activities. This would support a view that recorded audio data from the classroom can be analysed by the researcher to help them make a judgement about the participation levels of individuals in a group.

She (1999) also collected data to calculate the contributions students made to group discussion; using the data to look at the mean frequencies of student-student interactions with standard deviations calculated. She was interested in small group communication and physical engagement in the laboratory. Three seventh grade classes were investigated, from each class

was randomly selected one group of four boys, one groups of four girls and one mixed sex group (two boys and two girls). All of the students (with the exception of two boys) were of average ability or above. One hundred minutes of video recording were taken once a week for five and a half months. The data was coded in two ways to quantify the students' physical engagement and verbal behaviour. Transcriptions were made from the tapes and qualitative analysis of the verbal interactions took place. The data was then used to compare students working in single sex and mixed sex groups in the classroom. Here again, another researcher uses analysed recorded classroom talk as data to determine engagement with the task and along with my research to compare single sex and mixed sex groups.

Arvaja et al (2002) also used videotaping and audio recording as a way of collecting data in the science classroom. Their research took place in a Finnish Secondary School in the students' own classroom; an important point also noted above by Alexopoulou and Driver (1996). Researchers value the opportunity to examine students working in their own classroom as a way of collecting *real* data; real in the sense that if the students are working in their own classrooms they are more likely to be relaxed and behave in a natural way. An approach also adopted by Murphy & Hennessy (2001) who state the importance of being able to use a *'naturalistic case study approach to observing problem solving in context'* (Murphy & Hennessy 2001 p.207). My research involves the groups of students working in their own classroom, with their own teacher. The approach adopted here is to collect the data from two groups during the course of their science lessons, in as natural a way as possible, to be able to fully appreciate and describe the nature of classroom talk as it takes place in small groups.

Arvaja et al (2002) were investigating the interpersonal relationships when students work in small groups and how this affected classroom talk. A group of four 15-16 year old students (two boys and two girls) were randomly selected from among four randomly established small groups. In my study, the students were asked to organise themselves in to groups of

four and then I selected randomly a single sex boy group and the only mixed sex group in the classroom, random selection being a method used in other research in this field, as in the research of Arvaja et al (2002) and She (1999). In Arvaja et al's study the students and the teacher were interviewed before the project to find out about their interpersonal relationships and the teacher was asked for background information about the students. In my study as the students' science teacher and form tutor I know these students well and I am aware of their interpersonal relationships and background, an important point considering the need for authentic data to be analysed. There is no need for me to interview the students to get to know them, this has already happened as part of role as their form tutor.

The data in Arvaja et al's project was collected during laboratory experiments, reading scientific literature and analysing and reporting experimental findings. The data was collected by videotaping, interviews and field notes over six sessions (varying from nineteen minutes – one hour and thirty four minutes). The four hours of video tape were transcribed using verbatim transcription and non-verbal activity was also added to include the students' behaviour. The talk was then categorised;

- knowledge building talk, Mercer's categories of *critical knowledge building* and *uncritical knowledge sharing* were used
- other talk was categorised into *technical talk* and *off task talk.*

The percentage for each type of talk was then calculated in terms of time. The data was then used to make observations about the way that mixed sex groups learn in science. This approach is also adopted in my study, where verbatim transcriptions are also taken from audio recording with any details about tone of voice being added where appropriate. The talk in my study was then categorised using the categories identified in Chapter 2 and the percentage calculated for each category over the four activities; detailed later in this chapter. In Arvaja et al's study, transcriptions of classroom talk are seen as an appropriate data source to analyse talk using categories that make a judgement about whether learning is taking place. In my study,

Mercer's (2000) categories of *cumulative* and *exploratory* talk are used to analyse the data and both of these categories of talk demonstrate that learning is taking place.

Hogan (1999), worked with 24 8th Grade students (13-14 years old) in four classrooms, in a large suburban middle school in the USA whilst they were working on a twelve week unit constructing and testing mental models on the nature of matter. The students were split into eight groups of three where each child had chosen one other person in their group. The groups were mixed ability. The groups were observed three to four times per week over twelve weeks and were audio and video recorded (9-10 samples per group). Each session lasted between ten and forty minutes with the students being given questions to discuss. Six boys and six girls were also interviewed. The audio data was transcribed using verbatim transcription, paraphrasing, narrative description (for off task talk), the tape counter numbers were inserted to refer back to the tapes. Ethnographic interaction analysis procedures were used to generate analyses, this is where whole events were split into smaller episodes and then the patterns of interaction were then identified and interpreted (interactions were considered within a whole event). These interactions were then described as social roles with the roles being refined through examination of similar patterns across the transcripts. The data was used to develop eight social roles found when students work in small groups, these eight descriptions are used to identify the social roles adopted by the students in my small groups.

In my study, each episode of classroom talk, from the four activities was considered as a whole. The way in which the students interacted within the group was analysed. Using their talk, and the way they responded to others, their patterns of interactions, as individuals, were used to identify their social role during small episodes of talk, using Hogan's (1999) descriptions. A tally was taken of social roles and from this any consistent patterns were noted to assign each individual a social role within the small group. These social roles (Hogan 1999) are used to describe the way in which the students

interact when they work in their small groups. Important to note here, is that it was from audio data transcribed using verbatim transcription, that these social roles were identified. I have also used the approach described above in my study as a tested way of analysing the data to determine the social roles of the students in my small groups.

My project is aimed at exploring the effects of a specific intervention; that intervention being setting classroom activities that encourage the students to talk in their small groups and specifically instructing the students to talk and work together. This research methodology is similar to the work of Richmond and Striley (1996), Arvaja et al (2002) and Hogan (1999) in that audio data is used, transcribed and then the talk categorised using the categories derived from the literature review. In common with Arvaja et al's work, the percentage time students spend engaged in the talk described in each category and over the course of the activities is compared. Ethnographic interaction analysis procedures are also used to develop ideas about social roles (Hogan 1999), where the whole episode of talk is looked at in terms of smaller episodes and then interactions are identified where the students are described as adopting a social role in the discussion. As in the research of She (1999), mean frequencies of students interactions are also calculated and compared over the activities to explore if they change over time, with different activities or are subject to change due to social issues in the group. In using these methodologies, I attempt to provide a detailed insight into the two groups, and how the students talk in the classroom, to develop their understanding in science; using methods similar to other researchers as a means of increasing the reliability of my data. Locating my research findings within other research, will also increase the generalisability of my data. My research can be classified as *practitioner research* as it took place within my classroom where I acted both as class teacher and researcher.

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Practitioners' research – where does this study fit?

The overall approach being adopted in this research project is practitioner research in the classroom. Hopkins (1985) defines this as '*teachers who have extended their role to include critical reflection upon their craft with the aim of improving it*' (Hopkins 1985 p.1). Two roles are perceived by Hopkins; for teachers to improve their own teaching; or to test educational theory in practice. In this project I aim to do both; to improve my own teaching by examining the nature of small group work (and provide advice for other practitioners) and to test the educational theory as detailed in Chapter 2. Often practitioners are involved in Action Research where they introduce an intervention, reflect upon its effects and then develop further interventions into cycles of reflection. Nixon (1983) sees Action Research as the situation where teachers reflect on or investigate their own practice. This reflection upon my own practice happens, in depth, in this study although cycles of reflection do not occur. Cycles of reflection do not form part of this study because I wished to understand in depth and with detail what happens when students talk in small groups. I wished to find out what happened naturally (as is possible). This study seeks to investigate small group work with a view to improving it. I wish to learn from my own experience by reflecting on a real classroom situation and as a result of my reflections improve my own practice and offer advice to enable other practitioners to do the same.

This research aimed to study the effects of an intervention for students' learning in science. The intervention was that the students were encouraged to work in small groups and talk about the task set by the teacher. I have defined this as an intervention because I have changed my practice and the ways in which I would normally teach the students; the exact nature of this intervention is described in later in this chapter.

Stenhouse supports practitioner research in the classroom (quoted in Hopkins 1985) where he claims that it is only teachers, who are in the position to create good teaching and that;

> *The teacher is like a gardener who treats different plants differently, and not like a large scale farmer who administers standardised treatments to as near as possible standardised plants* (Hopkins 1985 p.28).

If the situation in the classroom cannot be standardised, across classrooms or indeed within them, then it is important that if teachers believe that something is important they should reflect upon and investigate it to improve their own teaching for their own students. Hopkins (1985) claims that practitioner research is seen as an attempt to understand a social situation and to '*derive hypotheses from that level of appreciation*' (Hopkins 1985 p.31). It is hoped that other practitioners will use this *appreciation* to inform their own teaching; in this study this will take the form of the advice offered to practitioners in Chapter 5.

Hopkins has devised five principles for *classroom research by teachers*:

6) There must be no disruption to teaching.
6) Data collection must not be too demanding on teacher time.
6) The methodology must be reliable to generate rich data that can help other teachers.
6) The research questions must be of genuine interest to the teacher.
6) Close attention must be paid to any ethical issues. (Hopkins 1985 Chapter 4)

The above principles were taken into account in the research design of this study, as I will go on to show. In summary, the research questions are of interest as they may improve the students' learning in science; surely this is the aim of any teacher. The research methods chosen; that is, the recording of classroom talk using tape recorders, and the writing of field notes as appropriate (the field notes being collected when I am not instructing the class), will help to ensure that there is little disruption to teaching and that the collection of data does not take too much time, ethical issues being considered as detailed later. One problem associated with practitioner

research is the issue of bias; in that it is a subjective activity. The problems associated with this may be mediated by the fact that as, an insider, this does provide the opportunity for detailed, authentic data to be analysed by a researcher who has a fuller appreciation of the context the data was collected in. A qualitative, ethnographic methodology will yield the rich data required as discussed below.

What can an ethnographic approach offer to this research project?

The approach adopted in this study is an ethnographic approach; this is defined by Hammersley (1994) in that it is characterised by the following features:

- The data comes from a *real world* setting.
- The data is collected from relatively informal observations.
- The data is unstructured in that the whole episode of talk is recorded.
- The focus is small in that it consists of two small groups of students working within the science classroom.
- The analysis takes the form of descriptions of the data and there is little statistical analysis (Only that which provides a greater insight into the data to support the descriptions).

Hammersley notes that an ethnographic approach is more appropriate for studying human nature than is an experimental approach; with ethnography people can be described acting in real situations. It is appropriate in this research as a methodology because *'it might be seen as well suited to the study of groups whose small size or secrecy make them inaccessible to survey research'* (Hammersley 1994 p. 4). In order to research classroom talk and the impact that it has on learning, detailed descriptions of the talk and how the groups work together, must be provided in order to contemplate all of the factors that are having an effect upon the group talk.

Hammersley goes on to describe three purposes for ethnography adopted as a methodology for research:

- *Naturalism,* where the aim of the research is first hand contact with human behaviour, this includes the analysis of *naturally occurring talk* (that is the purpose of this study). The importance of the context of the talk is also considered here.
- *Understanding,* central to this is an understanding of the context within which the research is set. Hammersley notes that this is particularly relevant for practitioners researching within their own classroom, where they are in a position to be able to act as participant observers. This was the case in this study, as I acted as a participant observer in my own classroom.
- *Discovery,* ethnographic approaches are where the researcher starts with a general interest in a real world occurrence and then throughout the research the focus is redefined and sharpened and even sometimes completely changed. This is not the case in this study as from the outset the research aimed to focus upon talk in small groups and I was directed in this by the various theories as discussed in Chapter 2.

Criticisms of ethnographic research maintain that it is imprecise and gives an *impression* of the data collected. The data is *subjective* because the researcher does not set out with a structure but responds to the data and situations that he or she finds. The data is not *generalisable* because it often relates to small groups in specific contexts. Ethnographic research could be said not to identify *causal relationships,* because it only looks at small groups within certain contexts. Ethnography is also unscientific because, it produces findings that cannot be repeated. Hammersley argues that this is not the case, by saying that ethnographic research does not seek to quantify data that could mislead the reader to assigning data significance and truth that it does not have. The data may be subjective, but the researcher may look at other ways to support their findings and therefore be involved in *triangulation* of the data to provide more evidence. As discussed earlier, the data in this study is triangulated by comparing it with the work of other researchers, this will help others to have more confidence in these findings

and so help them to be *generalisable*. *Generalisable* data may well lack the depth of description and discussion that ethnographic data provides and those researchers may have sacrificed quality for quantity. Whilst ethnographic data may not identify causal relationships it can describe in depth how relationships change over time. Not all natural science findings can be replicated and the fact that ethnographic data cannot be does not detract from its worth as research.

Taking Hammersley's five features of ethnographic research, I now discuss why it is that ethnography is an approach that can be adopted by practitioner researchers. It is an appropriate research methodology in that it allows teachers to collect data from situations, as they occur naturally, in their own classroom. It provides an unstructured way of collecting data; the teacher is well placed as an insider to collect this data by making informal records and notes of interesting features as they occur, or that are unusual or unexpected in this context, that is; the context of their own classroom. As an insider and a participant in the situation it would be difficult for the teacher to collect structured data in his/her own classroom. Collecting structured data could lead to a conflict of interest where the teacher can either teach or research, collecting data in an unstructured way can allow the teacher to do both at the same time, that is *through* their practice and the interactions that they make observations about them. Practitioner researchers will naturally have a small focus for their research as at any one time the upper limit is the number of students in their class. My experience in the pilot study (and in the main study) is that it is possible to make informal field notes of two groups of four students or it would be possible to work within a small group and make field notes during this interaction.

As an insider, the teacher is able to provide rich descriptions of the data. They can provide profiles of the students they are observing as they will have experienced teaching them over a period of time. An insider will also be able to identify and describe interesting features of the group work as they will have experienced a *normal* pattern of interactions to compare this

to. As for ethnographers it is descriptions of the data that are the main way in which analysed data is presented, as teachers are insiders in the situation they have an insight that can add depth, detail and colour to the pictures and stories they share about the interactions in their classrooms. There is a tension here between the detail an insider can bring to the analysis of data and the bias that may occur due to their involvement in the situation, it is not as easy to view the situation in an objective manner. This bias can be overcome by locating the analysed data and research findings within fields of existing, valid research and working alongside another teacher researcher and getting their opinion on the data; taking part in collaborative research if this is possible.

The purpose for ethnography in this project is to understand how group talk may influence learning and the factors that affect group talk. As stated above I acted as a participant observer and the data was analysed to take account of two factors: firstly, what were the students talking about, this would fit with *naturalism* as a purpose for ethnography where the *naturally occurring talk* was analysed, but, in order to understand why this talk was occurring I also had to consider the *context* for the talk; that is the factors that affect group talk such as, task or relationships in the group.

The data in this research is *generalisable* as it is analysed through the work of other researchers in the field and compared with previous research findings to identify similarities and differences and to contribute to the debate about group talk in science.

This research looks in depth at classroom talk in science when students work in small groups. I seek to describe the students' talk and the contribution that it can make to learning; I go on to discuss the factors that affect this talk. The data discussed in this research is a rich description of two small groups in this classroom. It can, though, offer much to other researchers and teachers. The data can offer science teachers descriptions of cumulative and exploratory talk in science so that they can identify this

within their own classroom. This research describes social roles as they are found in small groups and provides descriptions of the social factors that affect this talk. The findings of this research can provide other practitioners with a framework within which to investigate their own classrooms and reflect upon the important issue of how best to help their students learn in science. I go on now, to provide details of the specific intervention in this research.

A description of the intervention and the activities in this project.

This research set out to increase the amount of time that students spend talking in small groups in the classroom and then go on to investigate the nature of this talk. The lesson plans were modified from the Scheme of Work *Substances*, in each of the four lessons a specific time in the lesson planned, to include talk in small groups. At the start of the new topic *Substances,* the students were introduced to working in their small groups and it was at this time that they organised themselves into groups of four, allowing the students to choose their own groups is important if they are to share their ideas (Alexopoulou & Driver 1996, McAllister 1995). The tables were also moved in the classroom so that the students could work together easily in this way. By moving the tables, it was intended that, importance was placed upon the fact that these lessons were different and value was placed on the group work time. The students were then introduced to the specific activity (in each of the four lessons) and at the start of the group time I told them that they were now to work as a group and talk about the task. The students were told that they should try to solve any problems as a group and ask each other for help before calling me over to help them; this was to encourage them to talk together. I gave two instructions to the groups at the start of the time when they were talking in their groups:

- They should work as a group of four; to encourage all individuals to participate (Alexopoulou & Driver 1996, McAllister 1995).
- They should be talking and not writing; the reason for this was to encourage the groups to talk. It is through talk and interactions with

others that learning takes place (Vygotsky 1991, Rogoff 1990, Roth 1995).

These instructions were the same over the four activities; I go on now, to provide details of my research design.

Research design

- **My role during this research project.**

This study took place in the Science Department of a large, over-subscribed secondary school. My role during this project was twofold; firstly, within the school was that of a science teacher and I was also the Head of Department. In my role as the science teacher of this group, I taught them in my laboratory; I was the only teacher in the room with these students. I was also the Form Tutor of this group and so spent tutor time and science lesson time with them, during this time I came to know the students well. As their science teacher I taught them for three hours a week. In my role as Head of Department, I had responsibility for the science curriculum and leading the learning and teaching with the other teachers. Secondly, my role was as a researcher, which involved collecting the data analysed in this study. There are several tensions when occupying both of these roles in the classroom;

- it is difficult in a practical subject to lose a view of the whole class to focus attention on collecting field notes for the two groups
- the students may notice a change in the way in which I normally work and this may affect the data
- there is disruption to teaching when collecting the data.

To overcome these difficulties tape recorders were used to collect data, that is the group talk, and field notes were collected where this was possible; taking into consideration the demands of teaching and the students in a busy, authentic classroom. This fits with an ethnographic approach, aimed at developing understanding of classroom processes, as described by Hammersley (1994).

- **The Science Curriculum**

This research took place with students in their second half term. In their first half term at secondary school, all of the students in Year 7 study a unit of work called *Thinking like a Scientist*. This unit introduces students to the processes involved in scientific investigations. These include measuring accurately, making predictions, fair testing, collecting and analysing data and investigative science introductory work; preparing the students to plan their own scientific investigations, carry them out safely and analyse and evaluate their findings.

The next unit that the students study is *Substances*. This was a six-week scheme of work with the students taking part in three lessons per week (a total of 18 activities). The intervention described earlier, happened at the start of this topic *Substances*; data was collected on four occasions on subsequent activities; it was not possible to collect data on any more occasions due to the lack of opportunities to make use of the tape recorders to collect the audio data and the difficulties found in collecting the data and the disruption to my role as the class teacher.

In this topic, the students explored the three states of matter and ways in which substances may be classified. The students looked at models to show how particles are arranged in solids, liquids and gases and examined what happens to these particles when substances change state. They were also introduced to the concept of dissolving. During this time, the students were working together in their small groups during the lessons; data was not collected from when the students first started to work in this way, to allow them to establish this way of working. They were also audio-recorded before the data was collected, in the hope that they would get used to the tape recorders being on the table so that they would not be a cause of distraction and so that the data collected would be more realistic.

The following part of this topic looks at how substances are classified (grouped). The students were taught about the physical and chemical

differences between metals and non-metals and then go on to look at how to identify acidic, neutral and alkaline substances using *universal indicator paper* and *red* and *blue litmus paper*. They also learn to recognise how the colours given relate to a point on the pH scale and how this number relates to identifying acidic, neutral and alkaline substances.[9] It was during this phase of the scheme of work that the data was collected.

- **The Activities.**

In setting up this small group work in the classroom, Hennessy and Murphy's (2001) guidelines were followed as mentioned in Chapter 2. I wished to increase the amount of collaborative talk that my students were involved in, and I am committed to using small group work as a means of helping the students to learn in science. The tasks that were chosen were purposeful and authentic, in that, during Activity 1 and 2 the students were involved in developing their process skills and procedural understanding and through talking about these, during the activity, it was hoped that as a group they would be developing their conceptual understanding in science. These activities are authentic, as it is through the procedures and practical nature of science that new ideas develop in the wider scientific field. Activities 3 and 4, involved the students in reviewing their scientific ideas and were purposeful because they helped the students to prepare for their end of unit summative assessment, although they were not authentic scientific activities, the students would have used similar strategies in other subject areas and so they could be classified as authentic school activities. Specific time was allocated for the group talk, in each of the four activities where it was hoped that the students would discuss their ideas and develop a group ethos, whether they did or not is what this research hopes to describe. An overview of the activities follows:

[9] The pH scale numbers from 1->. 14. pH1 ->.6 are acids reds with UI & change blue litmus red. pH 7 is neutral green with UI no effect on red or blue litmus. pH 8-> 14 blues with UI turns red litmus blue.

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- **Activity 1 – Thinking about U. I. paper and the pH scale.**

The focus in this activity was to observe classroom talk during an investigative science activity where the students were summarising and looking for patterns in their results. The students had progressed to the part of the topic where they were classifying substances and were testing known acidic, alkaline and neutral substances with Universal Indicator paper. The students had solutions of the following substances:

hydrochloric acid
sulphuric acid
distilled water
sodium hydroxide solution
calcium hydroxide solution.

Before the practical activity, the aim had been explained to the students and the technical terms explained; acid, acidic, alkali, alkaline and neutral. I had told the students that hydrochloric acid and sulphuric acid were acidic substances, distilled water was a neutral substance and that sodium and calcium hydroxides were alkaline. This was to help the students to link the colours they observed with the terms acid, alkali and neutral. The aim of the activity was to find out how acidic, neutral and alkaline substances could be identified using Universal Indicator (UI) Paper. The students could also progress to linking the colour change observed on the UI paper, with a point on the pH scale.

The practical activity involved the students placing a few drops of each of the solutions onto a watch glass[10] using a pipette and dipping a piece of UI paper into the solution and noting the colour change. Each of the pairs also had a pH scale chart, which shows the colour of UI paper and its associated point on the scale described as a number e.g. pH 7 is green. The class was carrying out the practical activity in pairs, each pair testing all five solutions. They were then asked in their groups of four to come up with a

[10] A flat, round piece of glassware designed for holding small amounts of liquid.

written statement to summarise how they could classify acidic, alkaline and neutral substances using UI paper. The groups, initially were not given any prompt questions to structure their talk although after eight minutes some of the groups still did not have a conclusion and so at that point a sentence stem '*When you test acids the colour is . . .*' was shared with the class and written on the whiteboard to refocus the discussion. It was during this part of the lesson that there was a planned opportunity for the groups to collaborate and it was during this phase of the lesson, lasting ten minutes that the talk was recorded for both groups using a tape recorder. Field notes were taken, detailing how the groups were working together and whether they seemed to all be contributing and on task. Whether they seemed to be distracted by the tape reorder was also commented upon. Whole class discussion took place to summarise the activity and to come up with a written statement with which the whole class agreed. Field notes were taken of the two focus groups contribution to the whole class discussion.

- **Activity 2 – Red and blue litmus paper: what do they test for?**

The focus in this activity was again, to look at the classroom talk when students discuss their results from a practical investigation, but also to observe whether they use any of their findings from the previous lesson. The activity was designed to enable the groups to move further on in understanding of the concept of pH and how acidic, alkaline and neutral substances are tested using different types of indicator paper (UI and red and blue litmus). In the previous lesson, the students had explored the use of UI paper and its role in identifying acidic, alkaline and neutral substances. The summary of the previous lessons practical activity had been developed in the plenary of the lesson. The students had written in their books that UI is red in acids (pH 1>6), green in neutral (pH7) and blue in alkali (pH 8>14). In this lesson, they were to use the same method that they had used previously to test the pH of the range of household substances listed below:

Vim[11]

lemon juice

sugar

vinegar

tap water

salt

disinfectant

washing up liquid

toothpaste

cooking oil

washing powder

flour

bleach

milk

bicarbonate of soda

The method that the students had used before involved testing the pH of liquids and in this experiment the students had to mix any solids with water before they could easily test the pH of the substance. Any solids that they had were mixed with distilled water; the students had written in their books, from the previous lesson, that the pH of distilled water was pH7 – neutral. The students' task was to test a range of household substances with UI paper and blue and red litmus paper and to make observations to explain what red and blue litmus paper tested for. To do this, they needed to draw on the concepts explored in the previous lesson; they needed to be able to use their knowledge of the colours UI paper changed in acidic, alkaline and neutral substances. The students were to observe the following:

- Blue litmus changes red in acidic substances.
- Red litmus changes blue in alkaline substances.
- Both red and blue litmus remains unchanged in neutral substances.

[11] A brand named cleaning product.

In summary:

- Blue litmus can only be used to test for acidic substances.
- Red litmus can only be used to test for alkaline substances.
- On its own neither blue/red litmus can test for a neutral substance.

The students should have concluded that UI paper is the most *'universal'* way to test for acids and alkalis. It provides the most information, as it not only indicates whether a substance is acidic, alkaline or neutral it also gives a pH value and therefore indicates the *'strength'* of an acid or alkali.

The students carried out the practical activity and then discussed their observations in their groups of four; it was here that they were able to develop collaborative group talk about their results. It was during this phase of the lesson, lasting ten minutes, that audio-recordings were taken of the classroom talk for both groups and field notes were taken detailing how the groups were working together and whether they appeared to be on task. Again, I did not provide them with a structure for their talk, in that no prompt questions were given. The lesson concluded with whole class discussion to summarise the students' findings and to discuss whether these were accurate or not. Field notes were not taken on this occasion as the class had found this very difficult and had not managed to develop their conclusions so instead of whole class discussion I did a demonstration of the practical activity and then talked to them about the observations using questioning to develop the conclusion together as a class.

- **Activity 3 – Revision: Brainstorming activity about an aspect of the Substances unit.**

The focus of this lesson was to observe classroom talk during a science lesson where the students were using textbook resources and their own knowledge to summarise information about a specific topic. This lesson was part of a planned revision programme to prepare the students for their end of unit summary test. The *Substances* unit of work had been completed and the students were carrying out a review of the key ideas covered in the

topic. In the introduction to the lesson the students were told that they would be preparing for their end of unit test and carrying out some revision, as a class, over the following two lessons. In this lesson each group was given an aspect of the topic to research/review the key facts (scientific ideas associated with their topic) to feedback to the rest of the class.

Group A was given the subtopic *'Acids and Alkalis'* and Group B was given the task of recording the key facts about *'The differences between metals and non-metals'*. The class as a whole covered all areas of the topic.

The groups were provided with a large piece of paper and a thick felt tip pen, they had access to their exercise books and two textbooks to enable them to remember as many facts/scientific ideas as they could about their part of the topic. The students were provided with textbooks as an extra resource, to act as memory stimuli and also to allow for extension of knowledge through research for the more able students in the group. All groups were to find out as many facts as they could in twenty minutes; it was during this time that they could work collaboratively to complete the tasks. Their group work was structured by the fact that they had to write facts on the poster, in this activity they were not just talking. Group A and Group B were recorded throughout this time and their group poster was also collected. Field notes were taken of whether the groups were on task and how they seemed to be working together.

At the conclusion of the lesson, each group fed back to the class about what key ideas they had remembered and the posters were displayed around the room. Field notes were taken of how the groups went about this presentation to the class. All of the class had the opportunity to contribute further key facts that they felt had been missed during the plenary session at the end of the lesson.

- **Activity 4 – Question & Answer Revision Activity.**

The lesson was focused upon helping the students to revise specific science concepts and to observe that talk taking place during this. Each group was given five questions and asked to discuss the answers, as a revision activity. The questions were grouped around the three key themes studied in the topic *Substances*. These key themes were, the three states of matter, the differences between metals and non-metals and acids and alkalis.

The questions were used to carry out a review of the key ideas that the students should have visited during their study of the topic. These key ideas were reviewed the lesson before the test to remind the students of them. The sets of questions were passed round the groups during the activity so that each group would have a chance to talk about as many of the questions as they could. All groups had a selection of questions that covered part of each of the key themes listed above; there was an opportunity here for the groups to collaboratively review their ideas through their talk. Again, it is hoped that this activity will encourage *cumulative* and *exploratory* talk, where the students are involved in reviewing their ideas and explaining them to each other. The questions would also help to structure the talk for the groups. The group talk was recorded during this fifteen minute activity, the lesson finished with the teacher leading whole class discussion using the questions as a prompt for revision. In the next lesson the end of unit test took place.

- **The students**

The students, who took part in the data collection, came from a Year 7 class (7.8^{12}). A single sex group of boys and a mixed sex group of two girls and two boys were chosen randomly as detailed earlier in the chapter. Each group was mixed ability, based on their Key Stage 2 Science NCT[13] score and level; although neither group contained a student whose NCT score would identify them as below average.

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[12] 7.8 is the class name on the school timetable.
[13] These are the statutory tests taken by all students in state schools at the end of Key Stage 2 (11 year olds).

The students are listed below[14]:

Group A	**Group B**
Dale	Cassie
Sam	David
Liam	Robert
Stephen	Sarah

I go on now, to provide some further details about the groups, and the students as individuals, based on my experiences as their teacher and form tutor. These are provided to give some contextual information for the excerpts of talk detailed in Chapter 4.

Group A was a much quieter group, although all individuals were confident at speaking in small group and whole class discussion. They could be considered to be a *talkalike* group (Alvermann 1996) of quieter students. All of the boys in the group are well behaved and I do not have to intervene in their group work, there is no evidence of poor behaviour. All of the boys will ask for my help when they need it; if there is something that they do not understand. Individual profiles for each of the boys are found in Appendix b.

Group B could be considered to be a *talkalike* group (Alvermann 1996), in that it contained many of the more vocal members of the tutor group. As their form tutor and Science teacher, knowing the students well in a classroom situation, all individuals in this group had previously demonstrated that they were confident in both small group and whole class discussion. Group B, are a lively group of students who are good friends, they are unusual in this class in that they are the only mixed group of students who would choose to work together. They can be loud when they work together and can be drawn in to silly behaviour on occasion. I occasionally have to intervene in their group work because they are

[14] The names of the students have been changed for confidentiality.

obviously off task. Features of the individual students can be found in Appendix b.

- **The data collection techniques**

Listed below are the data collection methods that were used and a rationale to explain why it was felt that they were suitable for this research project.

Classroom observation

An unstructured approach was adopted here, where the aim was to describe the talk taking place when students work together in small groups in the science classroom. The information was collected as audio-recordings of the classroom talk, and field notes where this was possible, as noted above. The data from these unstructured observations was, firstly, reviewed to check that the collection methods provided data suitable for further analysis; that is, that the talk could be categorised and analysed as discussed in the summary of Chapter 2 (p.52). The data, provided opportunities for rich descriptions of the talk and group relationships when the students work in small groups in this science classroom.

Using Audio Recordings

The advantage of this method was that the data could be stored relatively easily, played and then reviewed. The method was suitable for recording the discussion that took place in small groups. The disadvantages were that it could be intrusive and background noise on the tape could cause a problem. Unless the researcher is familiar with the students then it may be difficult to ascertain who is doing the talking; knowing the students well, this problem was overcome in this study where the talk could be fully transcribed to include details such as tone of voice where this adds further detail to the talk. It is recognised that with audio recording, important contextual information can be lost. Field notes being taken at the same time (where this was possible) overcame some of these problems, where I noted how the students were working together, as described in the activities above. The classroom talk was transcribed for close analysis. Collecting the data as

audio-recordings is a useful way of collecting data that is not affected by the researcher and it also means that the data can be examined by other researchers. As a practitioner, this meant that I could teach and collect data at the same time. Another advantage of audio recording is that checking can bring about increased reliability of data. In this study, the tape reorder was used over a number of weeks so the students became more familiar with it. It was only possible to access two tape recorders at a time and so that was one disadvantage as the small group discussion could only be recorded for two groups at a time. The groups were recorded over the four activities as described above.

- **The process of analysis of the data**

The classroom talk was fully transcribed, during verbatim transcription any relevant information from the field notes was added and any other interesting features such as tone of voice, laughter etc. The data was then analysed in several ways.

The talk was categorised using Mercer's (2000) *disputational, cumulative and exploratory talk.* In order to do this the conversations had to be viewed in sections where the students were engaged in one type of talk for a period of time. Arvaja et al's (2002) categories of *technical* and *off task talk* were also used in the classification of the talk. In order to do this, I looked at words and phrases that seemed to indicate different types of talk. The definitions provided during Chapter 2 have been interpreted within the context of this study; samples of the students' talk for each of the categories being given in Appendix c to show how these categories have been interpreted within this project.

These categories were identified in the full transcriptions of classroom talk; these transcriptions were taken and then checked to add detail such as tone of voice. This was carried out to ensure that reliable transcriptions had been produced. I then went through and identified sequences in the talk which could be described by the categories described above. I carried out this

activity on three occasions to ensure that the talk had been reliably categorised before the data was used to calculate percentages.

The time that the students spent engaged in the different categories of talk was calculated as a percentage in the following way. The tape counter figures were used (1 unit of talk = 1 count) to calculate the time that the students spent engaged in each type of talk. These figures were then used to calculate percentage figures out of the whole talk episode. These percentages were calculated for each group and across the four tasks; analysis of variance was carried out on these figures to identify any significant differences across the tasks. Student's t-test was used to look at the differences between the groups. These observations helped me to make better sense of the data.

The data was also analysed to look at the contributions made by the individual students within the groups across the four activities. The purpose for this was to understand how the students engaged with the task and the group work and to identify any differences over the time of the observations. The tape counter figures were used to calculate percentages as described above and any analysis of variance used to analyse any differences within and between groups.

The talk was also described in depth to make observations about the outcomes of the talk, why did the students appear to be saying what they did? What did the talk seem to be used for by the groups? This analysis took place for each of the groups and any social issues that seemed to be arising from the literature review were noted, e.g. leadership issues, conflict. Hogan's (1999) analysis of social roles was carried out using ethnographic interaction analysis (as described earlier in the chapter) to provide an insight into the social roles adopted by the students as they worked in their small groups.

- **Ethical considerations**

All of the students involved in the study were asked for permission to record them. I explained before the observations started that I was interested in classroom discussion and that the students did not have to participate if they did not want to. None of the students objected to being recorded and they were assured that anything on the tapes was confidential. None of the data on the tapes was used to assess the achievements of any of the students; the students were assessed in a formative and summative way in an identical way to the rest of the class.

I move on now in Chapter 4, to present an analysis of the data collected in this study.

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April 2006

Chapter 4 Data Analysis

Introduction

This chapter is organised into two sections; the first section presents the quantitative data providing insights in to the types of talk identified across the tasks for both groups: Group A, a single sex group of four boys (Dale, Liam, Sam and Stephen) and Group B, a mixed sex group (Cassie, David, Robert and Sarah). Quantitative data will be used to provide an overview of the percentage types of talk identified during the group discussions.

This data was collected and analysed, over the four activities, as described in Chapter 3. In the second part of this chapter, the nature of the groups' talk will be further explored, presenting qualitative data from the transcripts and field notes. These qualitative and quantitative observations helped to make sense of what was happening in the small groups, during the time they were engaged in discussion activities. The aim of this analysis was to deepen awareness and understanding about group discussion in science and how the nature of the groups can affect the types of talk that are evident and how this can in turn affect learning in science.

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Table of comparative data to show the time allocated by the groups to each of the categories of talk previously identified.[15]

In the table below the data for Group A is in black and the data for Group B is in *italic.* The percentage of talk is shown for each of the categories and across the four tasks.

Type of talk	Activity 1	Activity 2	Activity 3	Activity 4	Average
Exploratory	12 (11) *0 (0)*	28 (30) *0 (0)*	0 (0) *0 (0)*	0 (0) *0 (0)*	10 *0*
Cumulative	21 (20) *8 (10)*	41 (44) *0 (0)*	16 (23) *10 (21)*	35 (48) *33 (30)*	28 *13*
Disputational	7 (7) *0 (0)*	0 (0) *0 (0)*	3 (4) *0 (0)*	0 (0) *0 (0)*	2 *0*
Technical	17 (16) *21 (26)*	0 (0) *15 (10)*	27 (37) *28 (64)*	29 (39) *12 (11)*	18 *19*
Off Task / Social talk	15 (14) *48 (59)*	7 (8) *51 (36)*	36 (50) *29 (65)*	6 (8) *31 (28)*	16 *40*
Quiet Time	9 (9) *8 (10)*	22 (24) *22 (15)*	17 (24) *27 (62)*	19 (26) *17 (15)*	17 *19*
Other	19 (19) *15 (18)*	2 (2) *12 (8)*	1 (2) *6 (13)*	11 (15) *7 (6)*	8 *10*

Key: Group A data *Group B data*

( ) Figures in brackets are the number of interactions for each category of talk.

* Percentages are rounded up of down to the nearest whole number.

[15] All figures quoted in Table 4.1 are as a percentage of the total time of the observation.

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Initial Observations about Group A

- It can be observed that the boys, generally, spend the majority of their time engaged in discussion about their work. That is in cumulative, exploratory and technical talk. This can be seen using the off task talk data that is generally a low percentage (averaging at 9% over Activities 1,2 and 4 and 36% during Activity 3) apart from Activity 3 where conflict developed during the group discussion as I go on to discuss later in the chapter.
- When the boys are talking about work, some interesting points are worthy of noting, firstly, exploratory talk is only found during Activity 1 and Activity 2. It is a larger percentage during Activity 2, where the boys found the activity more difficult. Activity 1 and Activity 2 were the investigative science tasks where the boys were using the data they had observed during the practical activity to develop a conclusion.
- Cumulative talk forms part of the group discussion in all activities. It is the type of talk that this group of boys are engaged in most of the time across the activities with the highest average percentage of 28%.
- Disputational talk is only evident during Activity 1 and Activity 3 and the percentages are very low averaging at 2%.
- Technical talk, accounts for 18% of the talk, it is more evident during Activities 3 and 4 and is not found at all during Activity 2.

Initial Observations about Group B.

- The data shows that the group spend more time talking socially than they do engaged in talk about their work. On average, the group spend 40% of time engaged in off task talk. Using student's t-test this has been found to be statistically significantly different ($p=0.05$) from Group A.[16]
- There is no evidence in the transcripts to suggest that the group spend any time at all engaged in exploratory talk.

[16] Student's t-test was the statistical test used. ANOVA was also carried out for the data. No statistically significant results were found. I have put this down to the small numbers involved in the sample therefore making it difficult to observe statistically significant differences.

- Cumulative talk averages at 13% with no evidence of this type of talk during Activity 2, 9% on average for Activities 1 and 3 with 33% during Activity 4. The task in Activity 4 was a more structured activity as described in Chapter 3.
- There is no evidence of disputational talk.
- Technical talk is the main talk engaged in (after social talk) averaging at 19%.
- The data suggests that Group B's talk appears to be influenced by the nature of the task, talk about investigative science leading to low levels of talk about work and the more structured tasks leading to an increase in technical and cumulative talk.

This section has provided an overview of the types of talk that the groups are engaged in over the activities. I go on now to present interesting features of the data from groups A and B (as described in Chapter 3); a qualitative presentation of the data is given with support from the quantitative data where this has other points to add to a fuller understanding of group work. Firstly, the types of talk are discussed with a view to examining what the group are doing when these types of talk are evident, what is the purpose of the talk and how does it contribute to the students' learning. The impact of social roles and the group relationships are examined to establish the effect that these have on both talk and learning in science. Included in the discussion of the group relationships is a consideration of the students' contributions to the group as individuals (as a percentage of time as described in Chapter 3).

The group work of Dale, Liam, Sam and Stephen is discussed first.

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Group A

Learning in science is linked with cumulative and exploratory talk: knowledge builds through cumulative talk, when students discuss their understanding in an uncritical way, that is, they do not question each other. During exploratory talk students question each other, they are required to provide explanations for their thinking and justify their points of view with evidence. As the quantitative data shows, exploratory talk is evident during the boys' discussion when they are working in their small group. This is linked with other ideas such as scaffolding, communities of learners, intersubjectivity and the development of conceptual understanding in science, as I will go on to show. Cumulative talk has already been stated as the main type of talk that the boys engage in and the nature of this talk will be examined particularly with reference to the development of procedural understanding in science. Disputational talk is also found and the circumstances that bring this about are explored further. The nature of technical talk will be discussed thinking about the times when this is used by the boys and what purposes it serves. Social talk will be explored, looking at what the boys talk about when they are not talking in a way that is developing their procedural or conceptual understanding in science and how they use humour to resolve conflict. The collaborativeness of the boys' group work will be identified, and then examined, to see how the social roles that the boys adopt during the small group discussion may help or inhibit collaborative work. Factors that affect this talk such as social roles and relationships will be explored and the potential impact that this could have upon learning in science.

The group discussion explored in this section is carried out over the four activities, as mentioned in Chapter 3, by the single sex group of four boys. In Activity 1, the boys are investigating the role of Universal Indicator paper, in Activity 2 the role of litmus paper in testing for acidic, neutral and alkaline substances. Activity 3 involves the group in brainstorming about the differences between metals and non-metals and in Activity 4 the boys

are using key questions given to them by me to review the topic *Substances* prior to an end of unit test.

At the start of the activities I invited the class to organise themselves into groups of four; the boys chose this group for themselves and so they can be considered to be a friendship group.[17]

- How talk is used by the group to support learning in science.

Three types of talk are used by the boys, all of them making a potential contribution to the boys' learning. I will go on to show how exploratory talk is used to develop conceptual understanding in science when the boys discuss and develop their ideas. Cumulative talk is used by the boys, to review existing understanding and knowledge in science and to discuss observations and data. Technical talk is needed to organise themselves to complete the task set by the teacher; it is through the activity of the task that the students are able to talk about their ideas in science and learn.

In the following extract, from the first activity, the boys discuss their understanding of the role of U. I. paper, during this exploratory talk develops. The group has completed the practical activity where they have tested known acidic, neutral and alkaline substances with U.I. paper. I have already identified with the class which of the substances they were testing were acidic, alkaline and neutral. One of my learning objectives for the session was to develop the students' process skills in science; the boys were learning how to use the U.I. paper and interpret their results. The group then went on to try to work out a sentence that could summarise their observations and explain the role of U.I. paper. The boys were already familiar with the terms *acids* and *alkalis* from their previous work on this topic. Another of my learning objectives was that the students would be able to interpret the colour of U.I. paper and link that with a value on the pH

[17] The boys sat together in their science lessons, PSHE lessons and tutor time. They also played together at break and lunchtime.

scale. The students would go on to recognise that red/orange/yellow colours represented acidic substances with values of less than 7 on the pH scale, that green was the colour of neutral solutions with a pH value of 7 and that alkalis would give a purple/blue colour and had pH values of between 8 and 14.

In this extract, provided to describe how *exploratory* talk is used by the group, the boys have just finished the practical activity; Liam asks me what they go on to next. I take this opportunity to stop the whole class to give them further directions. The class is told to look at their samples in the watch glasses with the U. I. paper and in their groups talk about what patterns they notice in their results and what information they can find out about a substance when they use U. I. paper. I tell the groups that they have exactly ten minutes to talk about this with their group. I also tell the class that at the end of this time they are going to share with each other what their results tell them about the role of U. I. paper. The following extract comes straight after my input to the whole class.

Extract A1

Stephen	*Did you get that?*	Stephen responds to me asking the group if they are clear about what they are going to do.
Sam	*Is it? . . . Right then, right then . . . Right in our small groups . . .*	Sam's response is an *initiating move,* he starts the group discussion by asking a question. He appears to be thinking out loud and although, trying to get the group started, seems unclear how to do this. Sam has seemingly taken upon himself the role of group leader.
Liam	*All the . . .*	Liam voices the beginning of a sentence

		they can use. Stephen, Sam and Liam all play a part in getting the group started.
Stephen	*acids*	Liam's use of *All the* seems to have helped Stephen to contribute the next word *acids*. Stephen adds further to the group rule, Liam's comment has *elicited* a response from Stephen.
Liam	*Were the reddy brown colour, No the pH1 colour,Yea?*	Liam responds to Stephen by adding a further part to the sentence, linking the word acid with a red colour and a pH of 1. Here Liam is *extending* the group discussion (he is building on Stephen's idea) and demonstrating his conceptual understanding about acids. Liam finishes with a *yea* waiting for the others to comment. He seems confused about whether to comment on the colour of the U.I. paper or the value this represents on the scale. The evidence suggests that Liam and Stephen work collaboratively here and help each other clarify their ideas.
Dale	*pH . . .No*	Dale does not agree with Liam's observations. Here Dale *qualifies* Liam's idea by rejecting it. Dale seems aware that the summary sentence needs to fit with all of the evidence.
Sam	*No we got pH2*	Sam supports this saying that in the practical activity, he and Dale observed pH2. Sam refers to evidence from the practical activity that does not support

Liam's conclusion. This is important as it focuses the group back to evidence from their practical activity that they need to use to develop the summary sentence.

Liam	*pH2?*	Liam repeats pH 2 while he is looking at the results from the experiment. One possible explanation is that he is prepared to change his summary sentence.
Sam	*pH? . . .*	Sam questions Liam again.
Dale	***I thought it was pH1***	Dale seems confused about what Liam is saying. He refers Liam back to his original observation.
Sam	*It's in the middle of them actually innit?*	Sam looks for a compromise in the observations, referring them back to the pH scale suggesting they could conclude a pH of 1.5 (the middle of 1 and 2).
Liam	*No **because** that's a black line!*	Liam questions whether this is a satisfactory explanation, noting the black line separating the colours observed for pH 1 and 2.
Sam	*pH1.5. It should be pH1.5 shouldn't it?*	Sam still questions whether pH1.5 is what they have observed and asks the rest of the group what they think.
Liam	*. . . **because** it's in the middle . . .umm . . . but then again pH1.5 because it's not fair.*	Liam still seems unconvinced and makes reference to it not being *fair* in some way, possibly because 1.5 is not a number found on the scale.
Stephen	*It's . . .umm . . .pH1 or pH2*	Stephen is unsure and refers back to the original observations.

As the extract indicates, the boys start the discussion by trying to develop the rule first rather than discussing their observations. They work collaboratively; this is demonstrated by the collaborative moves of *initiating, eliciting, extending* and *qualifying* as detailed above (Barnes and Todd 1977). Exploratory talk has developed here: evidence for this is that Liam provides reasons for his idea; Dale says *I thought* and Liam uses the word *because.* The boys' reasoning in evident in their talk; one possible explanation for this is the fact that the group share a *common knowledge (Mercer 2000)*, they have a *joint experience* as they have carried out the same practical and they have worked together before and so have a sense of *joint activity* (evidence from field notes suggests that the four boys were working co-operatively and talking together during the practical activity). The extract demonstrates that the boys talk in a critical but constructive way, they do disagree with each other but alternative explanations are given. Relevant information is offered for consideration by the group. The boys are involved in *interthinking (Mercer 2000)* as the language here is used to make sense of their collective experience. The developing conceptual understanding demonstrated in the boys' talk, has developed through their use of procedural understanding and exploratory talk.

In the extract, Liam shares his understanding about pH paper with the group and is trying to use appropriate language to do this. When Liam voices his understanding in the small group, the effect is that he makes his thoughts available to the rest of the group so that they can comment on them. Liam appears to be unclear when he is sharing his ideas; one possible explanation is that he is not fully confident about what the results from the activity show; he appears not to be certain about the colours observed for different pH values. Liam may not have the procedural scientific skills needed to help him to develop an understanding of the role of U.I. paper, or an alternative explanation is that Liam may take this viewpoint in the discussion because he is reluctant to disagree with Sam. This extract shows that although the group has successfully completed the practical task, they have not explained their observations. They appear unable at this stage to

share a sentence to describe their results with the class. One possible explanation for this is that there is not a *more knowledgeable other* who has the understanding and is therefore able to scaffold the learning of others, hence differential expertise cannot be developed (Cole 1985). The boys need a more knowledgeable other at the point where the extract ends. Dale and Stephen though, do support Liam in his learning, earlier in the extract, by the contributions that they make when Liam is voicing his thoughts. Dale and Stephen could be said to be offering different expertise as Stephen contributes content knowledge and Dale promotes reflection back to the data. Stephen does this by adding more information to Liam's sentence when he adds the word *'acids'*, this helps Liam to add into his sentence observations about the colour that U. I. paper changes in acid and to link this to a value *'the pH1 colour'*. Dale focuses Liam back on to the observations when he (Dale) links the *'reddy brown'* with a pH value of 2. There is no evidence to suggest that Dale and Stephen know more than Liam and yet they help Liam to develop a sentence by the differential expertise they develop, through acting in the social roles of *contributor of content knowledge* and *promoter of reflection.* It is through this that the groups' talk demonstrates conceptual understanding developing about the role of U. I. paper.

As the extract shows, the boys are working collaboratively as defined by Hennessy and Murphy (1999), the evidence suggests that cognitive resources are shared through talking together. The group are working like a '*community of learners'* (Rogoff 1995) where they are learning as they collaborate with each other.

Exploratory talk has developed here, as part of an investigative science activity and has been supported by the social roles of contributors of content knowledge and a promoter of reflection. The boys seem to accept Liam as the person who will develop the sentence; Liam's role here could be that of a *contributor of content knowledge* (Hogan 1999) (The boys seem to accept Liam as the scientific expert). The data provided about social roles later in

the chapter shows that this is Liam's main role in the group discussion. Dale, when he refers back to the observations, could be described as a *promoter of reflection* (Hogan 1999) as he prompts the group to go back and look at their evidence needed for them to develop their conclusion. The group is using their procedural understanding to develop their conceptual understanding of science.

Later in Activity 1, disputational talk develops. This happens only when the boys are put under pressure, by me, to complete the task quickly. It is used by Sam as a way of summarising group thought. The boys move from working collaboratively to Sam taking over and summarising the group thought on their behalf. The final summary sentence then is developed by Sam.

To bring about an end to the group discussion in Activity 1, I structured the task even more for the groups by saying to the class '*When you test acids the colour is . . .*'. I said this to the whole class and wrote the sentence stem on to the whiteboard visible to all the students. I reminded the groups that they would be asked to share their ideas shortly. My purpose for this was to structure the activity, for those who were finding it difficult, and to re-focus the groups back on to the task. This was after eight minutes of the groups talking together about their results. The following extract directly follows this input.

Extract A2

Sam	*Acids turn into pH1*	Sam takes over the start of the discussion (he also does this in extract A1). He starts his own sentence and does not use the sentence stem given by me to the class.
Dale	*I know acids that go*	Dale starts his own sentence again not

	on the	using the sentence stem given to the class, he is interrupted by Sam.
Sam	*Go on the, UI, Universal Indicator acids go to pH1 to pH2*	Sam modifies his response and adds on a reference to U. I. paper. Dale has elicited a response from Sam who goes back to the group's original idea.
Dale	*No, Sam*	Dale is still in disagreement with Sam, Sam ignores him.
Liam	*red*	Liam interjects the word *red*, one explanation for this is that he is using the my sentence stem. Sam ignores him.
Stephen	*acids*	Stephen links the word *red* with acids, Sam ignores Stephen as well.
Sam	*acids turn into pH1 to pH2 . . . while alkalis*	Sam continues to talk about his conclusion introducing the idea of alkalis.
Dale	*pH1*	Dale is repeating what Sam is saying and writing this down in his book.
Sam	*or whatever it is . . .*	Sam is unclear about the term *alkali.*
Dale	*Acids turn*	Dale is still writing down Sam's conclusion.
Sam	*to pH1 to pH2*	Sam helps Dale out by repeating part of his conclusion. Dale continues to write it down.
Dale	*while pH1*	Dale slowly writes down Sam's ideas.

Sam	*while alkalis*	Sam continues now to define alkalis.
Dale	*to pH2*	Dale is still writing down.
Sam	*to pH9 and pH11*	Sam completes his definition of an alkali.
Liam	*I'll read it okay?*	Liam has not spoken since his *red* was ignored, but now volunteers to read their conclusion out to the class. Dale and Sam do not respond.
Dale	*What is it?* *Acids turn to pH . . .*	Dale checks his sentence with Sam.
Liam	*pH11*	Liam responds to Dale, he is reading what Dale has written and tells him what to write next.
Sam	*pH11*	Sam confirms this.
Stephen	*What should we do?*	Stephen tries to open up discussion about what to do.
Liam	*I'll read it* *I've done it! Acids* *Turn to pH1 to pH2* *. . . while alkalis vary* *From pH9 to 11*	Liam again volunteers to read the conclusion, to the class. He says that he has finished writing down their group conclusion and reads it out for the rest of the group to check. Liam introduces the new word *vary.*
Sam	*What varies?*	Sam checks what he means by this.
Liam	*Yea*	Liam does not explain and just confirms that was what he said.

Stephen	*Yea but that's good.*	Stephen agrees that Liam's conclusion is good, he qualifies Liam's ideas working collaboratively with Liam. The discussion ends at this point.

As the extract indicates, the group is tantalisingly on the edge of generating a detailed and scientifically accurate sentence that summarises how the pH of a substance can be discovered using U. I. paper. They do identify, using their own words, that a substance that is pH 1 or 2 is an acid and that a substance that is between pH9 and pH11 is an alkali; they neglect to add into this conclusion, the colour their U. I. paper changed in each type of substance. The group has not made the link between the pH scale and how to use U. I. paper to identify the pH of a substance. The group did not discuss the sentence collaboratively, as they ignored it when Liam said red; tying this idea to the ones they were already discussing would have led to a fuller description of what they had found out. The group do not use their procedural understanding at this stage to help them to develop their summary sentence; they do not discuss their observations any further, as the extract shows. The boys have responded to my putting an end to the discussion by focussing on developing their sentence; or sharing with the class their prior conceptual understanding of pH and not their observations from the data. In extract 1, they did look at their results from the practical activity possibly because they had just completed it or because they had the time to do so. It may be the case that they did not do this in this second extract because they had to quickly develop their rule, so they reverted to their prior understanding to summarise their results.

The students are involved in repetition of their own thoughts and ideas. It can also be classed as *disputational talk* (Mercer 2000) as Sam is holding on to his own ideas and is not prepared to be dissuaded from his line of thinking even by Liam's observations. Sam is reasserting his own point of view and not taking into account the ideas of others. Harlen (2000) argues that this type of speech, where the students think out loud, in a sense, is very important in small group discussion as it helps the speaker to make sense of

his or her own understanding. In this extract both Liam and Sam are involved in sharing their summary sentence with the group; their utterances are disjointed and do not take into account contributions from others. The significance of this is that it seems that the boys stop collaborative talk, when the pressure of time puts a stop to discussion.

Liam does go ahead to share the group rule with the class:

Acids turn into pH 1 to pH 2 while alkalis vary from pH 9 to 11

It is interesting to note that the group also tested neutral substances but have not mentioned them here; the group have only explained what they found for the acids and alkalis. The group have not extended their rule to include the other values on the pH scale. The group did not include any observations about colour, one possible explanation for this could be that they value this observation less that an observation that includes numbers. The group have developed their conceptual understanding about the role of U. I. paper as they show that low numbers on the pH scale are acids and high numbers on the pH scale are alkalis, the evidence for this is in their group rule. The boys have partially met my learning objectives of developing their process skills and being able to use U. I paper and link with a value on the pH scale. They can use U. I. paper to determine the pH of a substance and they have demonstrated in their talk that red colours are low on the pH scale and that these substances are acidic (Liam in Extract A2).

Disputational talk (Mercer 2000) only accounts for 3% of the boys' time spent engaged in group discussion, it was only found on two occasions; firstly, as above when the boys became aware that they did not have enough time left to develop the group rule. At this point they stopped working collaboratively and Sam, the group leader, takes over to develop the group rule. In Activity 3, this type of talk was observed to be carried out again by Sam when he was writing on the group poster and in disagreement with Liam. Sam is the only member of this group who engages in *disputational*

talk, this is not a surprising observation, as Sam's teacher I have noted before that Sam is the type of boy who likes to get things done, he would not have been happy at all if his group had not been ready to make a contribution to the whole class discussion. Sam always likes to complete tasks on time and is a forceful person who will take over in order that this gets done.

During Activity 1, the data suggests that the boys use exploratory and disputational talk to talk about their conceptual understanding in science.

In the next activity (Activity 2), again a period of exploratory talk develops. The group are working through an investigative science activity where they are testing known acidic, alkaline and neutral substances with red and blue litmus paper to find out what they test for. The boys are using the same solutions they used in the previous lesson to find out about U.I. paper. I decided to use the same solutions, as the class already had experience of which substances were acidic, neutral and alkaline. There are two colours of litmus paper, red litmus paper changes blue in alkalis (it stays red in acids) and blue litmus paper changes red in acids (it stays blue in alkalis), in neutral solutions neither paper will change colour, so neutral solutions have to be identified using both pieces of paper where neither changes. My learning objectives for the lesson were that the students would further develop their procedural skills in science through involvement in practical activities and that they would develop an understanding of the role of a different indicator, litmus paper. The boys are talking about their results and they are trying to develop a summary sentence to share with the class what they have found out.

Extract A3

Stephen	*Blue is a higher pH . . .*	Stephen initiates the group discussion with an observation that a pink to blue change indicates a high pH.
Sam	*Pass it here Dale . .*	Sam, prompted by Stephen asks Dale to

	.what did you say?	pass him the watch glass to look at. He
	Blue is what?	repeats Stephen's conclusion.
	Blue is a higher pH than . . .	
Stephen	*What blue has a higher*	This elicits a further response from
	pH than red . . . you	Stephen who adds in the word red, he
	can't say that can you?	shows concern about the way he is expressing himself. He asks the rest of the group what they think.
Liam	*All the reds are . .*	Liam responds and starts the conclusion
	are between . . .	in a different way. He shows concern that
	nah we're gonna do	their conclusion is the same as the
	the same thing as pH1	previous lesson (Extract A1 & A2). He
	to pH4 aren't we?	asks the others about this.
Dale	*Yea*	Dale responds, agreeing that the conclusion does seem to be similar, he is interrupted by Stephen.
Stephen	*and we can't have the same.*	Stephen also agrees that it can't be the same.
Liam	*All the reds . . .*	Liam starts to repeat his conclusion but he is interrupted by Sam who says he is reading Liam's conclusion.
Sam	*I'm reading yours*	Sam seems to think that it is a better or.
	Because yours is	clearer explanation than his own.

	clearer	
Liam	*All the reds are low on the pH scale and the blues are higher up.*	Liam repeats his conclusion this time using the terms *low* and *high* rather than the values on the pH scale.
Stephen	*That's the same as our last one.*	Stephen points out that this is still the same.
Dale	*pH scale*	Dale repeats Liam
Stephen	*Yes but the question is . . .What do blue and red litmus paper test for?*	Stephen repeats the question set by me and in doing so focuses the group back to the task and the question they are trying to answer. It is interesting here that the boys refer back to the question, but data from the field notes shows that during their talk they are not seen referring to the results table they have developed.
Dale	*What do they test for?*	Dale repeats part of the question focussing on the fact that they are trying to find out what they test for. The group do not appear to have made the link between red and blue litmus paper and the terms *acids* and *alkali*; they do not use these words in their group talk. The boys seem to be using their own words rather than technical terms in their talk.

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The boys have used *cumulative talk* here to discuss the results from their observations. Through their talk they have attempted to collect all of the relevant information they need to develop their summary sentence. Knowledge has accumulated up until this point in the discussion, based on the observations they have made. They have not questioned each other though or offered any explanations for their observations; they go on to do that next, in the period of exploratory talk that follows.

Extract A4

Stephen	*I don't get it . .*	Stephen shares with the group that repeating the questions has not helped him in developing the conclusion.
Liam	***I still think** it's all the red ones are lower on the pH and all the blue ones are higher.*	Liam repeats his previous conclusion.
Stephen	*That's what I was trying to say . . .**because** I was looking at this.*	Stephen now agrees with him and points out that he is looking at the results from the experiment.
Liam	*Shall we go with that?*	Liam asks the group to agree with his conclusion.
Stephen	*I don't know . . .*	Stephen still seems unsure.
Sam	*All the blues are higher than the reds . . . The blues*	Sam repeats Liam's idea in a slightly different way, starting with blue. He says it twice, appearing to think out loud.

are higher than the reds.

Liam	*The orange, orange red colours on the pH scale are lower than the bluey ones.*	Liam is laughing now and repeats his conclusion adding in some other colours.
Dale	*What do they test for?*	Dale is still not convinced and again refers them back to the question that preoccupied him earlier that their conclusion does not explain what blue and red litmus paper test for.
Liam	*Ah, you've confused me now!*	Liam laughs and says that he is now confused. One possible explanation is that he is aware he has not answered the question.
Dale	*Idiot*	Dale is also now laughing.

**The boys are silent for two seconds.*

Stephen	*Shall we just say it?*	Stephen suggests to the group that they say this, possibly because nobody else has offered a better idea. Stephen may be concerned that the group is not going to be able to make a contribution to the plenary of the lesson. If Liam is becoming confused maybe Stephen thinks it unlikely that the group are going to develop a better explanation of the evidence.

No one responds to Stephen and after a quiet period Dale starts the group off on the off task talk that follows.

The group demonstrates *procedural understanding,* in that they are concerned with the question 'What are we looking for?' The boys know that they need to use the data from their observations to develop their summary sentence and to reflect back upon the question they were investigating. In the extract above they try to use the colours they have observed to answer the question set by me. The boys again, act as a *community of learners (Rogoff 1994)* as they are learning through their collaboration with each other during their activity. There is evidence of *social interdependence (Rogoff 1990)* as the boys are working together to talk about the conclusion. At the end of the extract the group are not fully convinced about their summary sentence. Again the group appear to be without an expert or *guide* and therefore development of their understanding appears to stop and a person with increased scientific knowledge is needed.

The boys can again be seen to be engaged in *exploratory talk (Mercer 2000).* The talk is critical and the boys' reasoning is visible, the boys ask questions of each other and use words like *I think* and *because.* Again *exploratory talk* is used as a strategy, to help the boys in their development of conceptual understanding in science. The quantitative data (Table 4.1) shows that the boys spent 28% of the total time engaged in exploratory talk. The increased time during Activity 2 could be because the boys find this task more difficult, they are not happy with the summary sentence they develop and so spend more time talking about it. It is during this activity that Sam, the most talkative boy in this group, makes the least contribution as Table 4.2 shows. The boys have also shown evidence that they will use the third aspect of *common knowledge (Mercer 2000)*; they refer to their learning from the previous lesson and in doing so demonstrate collective remembering.

Here the group are putting all available energy into solving the problem and they are working together effectively and collaboratively. The students are able to be flexible about their roles in order to solve the group problem; individuals are seen to adopt a role that helps the talk to move on. Hogan's (1999) roles in group discussion can be used to analyse the extract: Stephen is seen to act both as an initiator of discussion and *promoter of reflection*, he brings the group (with Dale) back to the question and repeats his ideas for others to comment on. Liam acts as a *contributor of content knowledge*; Liam brings the group's attention to the colours observed and links this to the pH scale. Dale acts both as, *promoter of reflection* and *mediator of group ideas*. Dale mediates the group's ideas by continuing to focus them back on to the original question. The group is flexible in their attempts to complete the task, in that the boys will adopt the social role needed at that time. These important roles are evident in both of the extracts where exploratory talk is found. The boys' social roles have changed little in the small group discussion during the first two activities (as the above extracts show).

The issue of the summary sentence to conclude this practical activity is left unresolved. This is fundamentally because the group appear to be trying to link the colours observed with litmus paper to the pH scale whereas what they need to do is link the colour changes whether the solutions they are testing are acids or alkalis, specifically with these terms. The boys use their own words rather than the technical terms, one possible explanation for this is that they are not clear how acids and alkalis may be defined and so find them difficult to use in the talk. The group seem to value the pH scale as being fundamentally important in determining whether a substance is an acid or alkali. Litmus paper is not as sophisticated an indicator as U.I. this could be causing the boys uncertainty.[18]

[18] Litmus paper only changes red->blue with alkalis and blue->red with acids.

The boys, by the collaborative nature of their group talk; allow exploratory talk to develop. The data shows that the boys do share ideas and listen to each other; they talk one at a time and do try to give reasons and explain their ideas. The boys' talk shows that they are working within their own framework that has similarities with Mercer's (2000) ground rules for exploratory talk. The boys have not been taught these rules but they do appear to talk in a way that reflects them. The boys do develop talk that is collaborative in nature, and they initiate interactions with each other. Nowhere, in the extracts above, do the boys request the support of the teacher. The extracts show that, not at any time, have they worked as individuals, even when Sam is developing the rule in extract A2 the rest of the boys are waiting for him. This evidence suggests that this group of boys does not work together in a way that has been described as typical for all boy groups.

- How talk is used by the group to organise themselves to carry out tasks in science.

Evidence from the transcripts shows that technical talk is used to organise themselves to start the task in Activity 3, to distribute responsibilities or in Activity 4, talking about who will read the questions and make decisions about who will feedback the group ideas to the class. Technical talk starts off the group discussion and this indicates that technical talk is important in getting the group talk started.

The following extract from Activity 3 is an example of technical talk being used to distribute responsibilities within the group. This talk is important for the group, because if they cannot get organised to carry out the task then they will not bet involved in talk that will help them to learn. The group has been asked to find out information about acids and alkalis and include this on a group poster (Activity 3). My learning objectives for the activity were that each group would take a section of the topic and review it as a group and that they would share their group ideas with the rest of the class. The

class would also be developing social skills as they were approaching the task as a group and learning how to share their ideas with the whole class. All of the groups in the class are producing posters summarising key information about the ideas that the students have covered during this topic *Substances*. During the plenary of the lesson each group will share their poster with the rest of the class. I have already introduced the task to the boys and offered an appropriate textbook to one of the students (Sam). I have also guided students' attention to page 48 of the textbook, offering in this way a starting point for their task:

Extract A5

Stephen	*Turn to page 48*	Stephen reminds Sam that I have suggested that they look at p.48.
Sam	*Page 48*	Sam repeats him and turns to the right page.
	Whose gonna write the first thing?	He then asks who would like to write, by asking, he is taking a lead in organising the group.
Liam	*Do you want me to? write it?*	Liam volunteers to do this.
Sam	*Right you write the first thing. Bagsy writing the second thing.*	Sam agrees to Liam's request and then says he will write the second.
Dale	*Bagsy writing the third thing . . . Stephen you're*	Dale joins in volunteering to go next. although he is aware that Stephen has not yet claimed his turn.
Sam	*. . . writing the second*	Sam suggests Stephen takes his turn. One possible explanation for this is that Sam,

acting as group leader is reminded by Dale of the need to include all of the group.

Dale	*Yea . . .but we've all got to work in a group*	Dale draws Sam's attention to this in a direct way.

It is interesting to note here, how the boys organise themselves and this gives an insight into the ways in which they work together as a group. Sam likes to organise them, this is not surprising as Sam likes to complete his work on time and as they have only been given a certain amount of time to complete the task will be aware that they have to get started. Dale works well with others and is a gentle boy (as detailed in the profiles Appendix c), who is good at getting others to work as a team so it is not surprising that he draws Sam's attention to the fact that Stephen has been left out. Liam is always a ready volunteer, so it is not a surprise that he asks to go first. These issues do have to be resolved if the group are to work together collaboratively and it is possible to note that technical talk does have a role to play in small group work. Field notes show that the group did change the scribe around and that they were working as a group of four, Stephen was observed to write on the poster.

The extracts so far show that it is through technical talk that the group get themselves started on the activity (Extract A5), that cumulative talk is used to discuss the results from their observations in science (Extract A3) and that exploratory talk is used to discuss understanding of scientific ideas (Extract A1, A4). The boys will resort to disputational talk if they are put under pressure to complete the activity. These types of talk are used by the boys to support talk about their learning in science. I move on now to examine off task talk and its purpose for the boys and their group work.

- Off task talk and its role in science group work.

As I mentioned in earlier in the chapter, this group spent 16% of its time in off task or social talk. Here, I explore the role of this talk in bringing about group cohesiveness, breaking the silence and resolving social conflict.

Before the following extract the group had been carrying out the practical activity as described in Activity 1. The group are in the process of trying to discuss their group rule but they have become sidetracked on to a period of off task talk (that not directly related to the task). In this first extract, the boys use humour to discuss safety in science and demonstrate that there is a good working relationship in this group. This talk can be defined as off task, as it is not directly related to the task; the boys are supposed to be talking about the role of U. I. paper (prior to this the boys have been discussing this).

Extract A6

Stephen	*That one accidentally dripped there!*	Stephen points at the desk in front of him. He draws the group's attention to a spillage of chemical on the table. Stephen says that this is an accident.
Liam	*Yea look we've had two accidents*	Liam points to the desk in front of him, he notices that there are two spillages of chemical. Liam is giggling at this point.
Sam	*Yea one with the water because we got some stuff all over our hands!*	Sam also joins in the joke, he explains to the others that one of the spillages is only water. The water is from when they Had to wash their hands because they had some chemical on them. He sounds very excited about this and is also giggling.
Liam	*Yea, yea and we got acid on our hands so*	Liam goes further to explain that it was actually acid that they spilt on their skin

	we went aaarg and ran to the taps.	and speaking in a dramatic way explains that they had to move quickly to the taps, He implies that when they had the acid on their skin it hurt. Liam comically says aarg and moves his hands towards the taps.
Sam	*No actually we were right next to the taps so we couldn't run to them.*	Sam points out, still laughing that actually they sit right next to the taps and implies that Liam is exaggerating.
Liam	*Okay we did a big step to them. That's more like it but it wasn't!*	Liam still maintains that he had to move to get to the taps. All of the boys are laughing and joining in the exaggerated exploits of Liam.

The boys start the extract talking about safety but do so in a humorous way, one possible explanation for this off task talk is that it is helping the boys to develop group cohesiveness. The extract provides evidence of group cohesiveness in this group of boys; they can share a joke, all of the boys are heard on the tape to be laughing. From my knowledge of these boys as their form tutor, this type of talk is typical of this group of friends who, as individuals, all show a good sense of humour. This is observed in the University of Keele (in Barnes & Todd 1977) study where groups can spend up to 25% of their time talking socially and this can have a positive impact on the group. As I go on to show, the boys also engage in off task talk to successfully resolve conflict. The off task talk in this group does not seem to get in the way of their work and it does seem to help the boys to develop their group relationships. The extract shows that although the boys are not directly working on the activity as directed by the teacher, they are still talking together as a group; this is unusual in single sex boy groups who are often found to work as individuals (Murphy 1998, She 1999).

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This next extract is taken during the brainstorming in Activity 3, the students are writing down facts about acids and alkalis on a large piece of paper, the group is starting the activity and are getting themselves organised about who will write down the facts on the paper. In the extract, technical talk is being used by the boys to clarify their roles and to organise themselves to complete the task. Procedural conflict develops, where the boys cannot agree what to do and this develops into social conflict. Off task talk and humour are used to resolve this conflict and to help the group to get back on with their work as the following two extracts show.

Directly before this, extract A5 has occurred, Sam starts by asking who is going to write the first thing. Liam volunteers and then Sam very quickly says that he will write the second key idea. Dale explains that he would like to write the third but that Stephen should write the second. Dale says that they are all one group and not just one person. Sam agrees with Dale's suggestion and Liam challenges him. Sam goes on to say that the order should be Dale, Sam, Liam, and then Stephen and following this is the extract below.

Extract A7

Sam	*No, right Dale, you, me, Stephen. Yea we'll go like that!*	Sam organises the group to write on the poster. He is deciding the order they will write.
Liam	*Look Sam's controlling us all again!*	Liam is seen to challenge Sam's right to do this and seems to object to Sam's assumed leadership of the group.

Dale	*I'm not bothered!*	Dale shares with the group that he is happy to go with whatever Sam has decided.
Liam	*I am! Sam reckons he's in charge every time we have to do group work!*	Liam (speaking in an annoyed tone) clearly shares with the group that he is not happy for Sam to make the decisions on their behalf claiming that Sam always assumes that he is in charge.
Sam	*Oh yeaaaaa!*	Sam in tones showing equal annoyance, disagrees with Liam.
Liam	*Yeaaaah!*	Liam, strongly, again challenges Sam, arguing with him.
Dale	*Just tell me the facts. Hurry up and stop messing about!*	Dale appears disinterested in this and attempts to bring the group back on task. He calmly tells Sam and Liam to stop being silly.
Liam	*That's exactly how we feel with you. Maybe you don't realise!!*	Liam continues to argue with Sam, he uses the term *we* claiming to be speaking on behalf of the rest of the group. Liam sounds angry and although, he claims to be speaking on the group's behalf receives no support from Stephen and Dale.

Sam	*I'm just saying shall we go this way then!*	Sam tries to explain that he is asking a question and not giving them orders.
Liam	*You don't realise that you do it but you do, do it!*	Liam explains to Sam that he thinks that he (Sam) does not realise how much he tries to control the other boys, he stresses to Sam that he does indeed order them around.
Sam	*I don't!*	Sam, again, angrily denies this.
Liam	*You do*	Liam strongly puts his point of view forward again.
Sam	*You do*	Sam turns the argument around claiming that it is Liam who attempts to organise the group (there is no evidence for this in the transcripts, or in the field notes, or in my knowledge of Liam).
Liam	*I don't take charge and go right you do this, you do that . . .*	Liam denies this in an angry tone and his voice is getting louder.
Stephen	*Hydro . .*	Stephen appears to be ignoring them and trying to start the task.
Sam	*I don't say take charge . . . I don't*	Sam is still very concerned with denying Liam's allegations.

Stephen	*Shall we put acids? Are you allowed to put like different acids?*	Stephen is more direct this time and asks a question to refocus the group.
Sam	*umm . . . Acids and alkalis facts about them . . .*	This time Sam responds to Stephen. He seems to be now joining in the task.
Dale	*What one was that? You read it out and I'll write it.*	Dale also now joins in this talk about work. He offers to write, as Sam suggested earlier. He asks Sam to read out his idea and then he (Dale) will write it on the poster.
Liam	*We've got ten minutes.*	Liam, in a much calmer tone, draws the group's attention to the time they have left to complete the task.

It is evident from the extract above, that there is a breakdown in the group relationships. There appears to be a challenge to Sam from Liam, or at the very least Liam objects to Sam assuming a leadership role. In the previous activities it seems that Liam does not object to the way Sam is interacting in the group and appears to be quite happy with his role as a *contributor of content knowledge* (Hogan 1999). Dale attempts to mediate the group relationships and tells Liam and Sam to get back on task by instructing them to tell him the facts and stop messing about. He is attempting to initiate group discussion about the task and makes no attempt to move on in the task without the rest of the group. Stephen, attempts to stop the argument by his use of questions to get the group back on task. Sam responds to Stephen, one possible explanation for this, is that it is an attempt to maintain his role

as the group leader and he tries to start off the activity again by restating the task. Dale, as the extract indicates, takes on the role of *mediator of group interactions* (Hogan 1999) and attempts to organise the group. Dale draws a close to the argument by bringing the groups' attention back to the task. Liam makes a contribution by sharing with the group that they only have ten minutes, this is possibly an admission that they need to get on with the task and that the arguing is preventing them from getting on with their work.

The conflict here happens because Sam takes upon himself the role of group leader when the group has not agreed this. Sam's claiming of the leader's role is evident when he attempts to take responsibility for organising the group. He argues with Liam who appears not to want to lead the group himself but objects to Sam's assumption that it is okay for him to do so.

Off task talk and humour are used to resolve the social conflict above, as this extract, taken from shortly after the above interaction shows. It can be seen that Liam is still very short tempered and Dale has taken on the role of the leader but in a different way. Dale is writing the group ideas on to the poster and the others are feeding him the ideas to write down. The students are keen to produce an answer and this goal unites them.

Extract A8

Stephen	*Put it in short words*	Stephen initiates the group talk, telling Dale to make the poster a summary.
Sam	*Write red litmus tests for alkalis*	This elicits a response from Sam who tells Dale one key fact about alkalis.
Stephen	*Red litmus*	Stephen is slowly repeating Sam so that Dale can write down his idea.

Liam	*Dale just write! . . .*	Liam's tone of voice indicates he is still very short tempered, he may feel that Dale is not writing quickly enough. He tells Dale in a bad tempered tone to write.
Dale	*Red what?*	Dale asks what comes after red. He is writing slowly!
Sam	*Litmus . . . litmus*	Sam whose tone shows that he is becoming irritated repeats the word twice.
Liam	*L I T*	Dale still hasn't written it down and so Liam, in a more frustrated tone starts to spell out the word.
Dale	*I know!!!*	Dale, in a tone indicating annoyance lets Liam know that he does not have a problem with spelling the word.
Sam	*tests for alkalis*	Dale has written 'red litmus' and Sam now repeats the second part of the idea for Dale to write down.
Stephen	*and then we can put blue litmus tests for . . .*	Stephen goes on to suggest the next idea they could write on the poster.
Sam	*and then put blue litmus . . . no put alkalis*	Sam interrupts Stephen telling Dale what to write on the poster. Dale is finishing off writing the first idea.

Stephen	*No we can put that in another one, then we've got more facts*	Stephen has the idea of writing his idea down separately as then they will look like they have more ideas.
Sam	*Right then . . . my turn*	Sam shares with the group that it is now his turn to write.
Dale	*Liam, instead of watching you can like try and think of one!!!*	Dale tells Liam to join in and not just watch what is going on. He asks Liam if he has any ideas. Liam may not be joining in as he is still annoyed about his conflict with Sam before.
Liam	*Look at Stephen man! And Sam's holding the book!!*	Liam draws attention to Sam and Stephen implying that they are not working either. His tone is still angry.
Dale	*Yea but at least he looks like he's thinking!!!!*	Dale is laughing and says that at least Sam looks like he is thinking.
Sam	*I'm not holding the book*	Sam, in an irritated tone disagrees with Liam.
Liam	*Yea you were Okay*	Liam responds angrily appearing to want to start the argument again. He holds his hand up to Sam to stop Sam talking.
Sam	*Why are you doing this with your hand? How!!*	Sam mimics Liam, copying what Liam is doing with his hand. Sam's

Pleased to meet you too!! tone does not suggest anger but amusement.

Liam	*Water is neutral*	Liam now contributes an idea that the group can add to their poster. His tone indicates that he is still a bit annoyed but clearly from his response he is prepared now to join in and make a contribution to the poster.
Sam	*Is that what I'm writing water is neutral?*	Sam is now laughing and checks with Liam about what to write on the poster.
Stephen	*Yea . . . well it is!*	Stephen, also laughing, supports what Liam has said, he qualifies Liam's idea. The group go on to work collaboratively and finish the poster together.

The extract shows, that Liam challenges Sam about his leadership of the group. This may damage the group working relationship and in doing so Liam is acting as a *promoter of acrimony* (Hogan 1999). Liam, as noticed by Dale has stopped participating in the group work. Dale then challenges Liam to join in; here Dale is acting in the role of a *mediator of group interactions* (Hogan 1999), where his contributions help the group to complete the task set by the teacher. Liam draws attention to Sam and Stephen whom he implies are not doing very much either. Dale uses humour and explains that at least Sam looks like he's thinking; implying that Sam has moved on from the confrontation and is now joining in the group. Liam attempts to start to argue again with Sam, and this time Sam uses humour to lighten the situation by mimicking Liam's hand gesture. Liam responds by making a contribution to the group poster, Sam laughs

and writes this down. One possible explanation for Stephen's contribution is that he is keen to maintain the new calmness so he supports what Liam has said. Dale may have resolved the conflict by using gentle pressure; he does not allow Liam to sulk and not join in. Dale is using gentle pressure, humour and jokes to avert anger and get the boys working together on the task. The poster collected in from the group shows that they did complete the task set and field notes taken during their feedback to the whole class show that Sam was the spokesperson, but that they shared the task around the group. They were observed to work very co-operatively, to quote from the field notes; the boys were *very good at sharing tasks equally among the group*.

A whole cycle is observed here, where the group has a conflict and then that conflict is successfully resolved as the boys continue to work collaboratively. Dale's mediation within the group seems to help them all to join in with the group work. Dale's example of humour seems to help Sam to use a similar approach to resolve his differences with Liam (where Sam mimics Liam's hand gesture). In fact, Dale appears to insist upon this, he is proactive about getting Liam to respond. In this extract he succeeds through his conversation, to make Liam join in with the group and contribute to the group poster.

Off task talk is an important part of group work and is used by the group to develop their working relationships and to resolve social conflict.

- The individual's contribution to the group discussion across the four activities.

The purpose of this section is to provide data, in the table below, to examine the percentage of interactions for each of the students across the four tasks. Using this data provides more information about the discussion in this small group.

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Table 4.2

% talk of students	Activity 1	Activity 2	Activity 3	Activity 4	Average %
Dale	20 (23)	25 (26)	18 (26)	30 (44)	23
Sam	31 (36)	19 (20)	39 (58)	34 (50)	31
Liam	31 (36)	27 (28)	29 (43)	20 (30)	27
Stephen	18 (20)	29 (30)	14 (20)	16 (24)	19

( ) Figures in brackets are the number of interactions for each student.

It is interesting to note that Dale's contributions change across the activities, increasing in Activity 4, after the social conflict (Activity 3). This could be associated with his role of the mediator of the group during Activity 3 and 4, as described in extracts A7 and A8. Dale is only required to do this during these activities, but when this role is needed in the group, Dale is able to act in it. Sam always has the most to say except in Activity 2 where Liam, Stephen and Dale are involved in exploratory talk as described above. In this activity, the boys find it difficult to develop a summary sentence and as the extract shows Sam does not join in the discussion except to repeat what the others are saying. One possible explanation is that Sam may be reluctant to share his ideas if he is unsure about them. Liam's contributions decrease slightly after the conflict but this could also be explained by the type of task in Activity 4 that helps the others contribute content knowledge.

Stephen's greatest contribution is in Activity 2 where he is uncertain about what Liam is saying and prompts further reflection about the group summary sentence.

The average figures are unsurprising, given my knowledge of these boys. Stephen and Dale are quieter students than Sam and Liam. Liam and Sam

would both be happy to contribute to whole class discussion, whereas Dale and Stephen would only do this if they were asked and Stephen would be reluctant even then. What the figures do suggest is that all of the boys join in the group discussion and there is no one individual who takes over the group talk.

- The social roles demonstrated by the boys during the group discussion.

The data in the table below is a tally of the social roles adopted by the group over the course of the activities, including data not used for the extracts above. The way in which these figures were developed is found in Chapter 3:

Table 4.3[19]

Social role adopted by student.	**Liam**	**Sam**	**Dale**	**Stephen**
Promoter of reflection	1		4	5
Contributor of content knowledge	16	8	6	5
Mediator of group interactions			3	
Promoter of acrimony	7	1		
Promoter of distraction	1			

I go on now to summarise the key ways in which the boys work together in this study, Dale shows similarities with an *inclusive leader* as described by Richmond & Striley (1996) in that he includes all of the group in the discussion and appears to insist on this (Extract A4 and A8). This is further demonstrated by his use of the term *'We've'* and his ability to use gentle

[19] The data for this study shows that none of the boys in this group act in the roles of *creative model builder, promoters of simple task completion or unreflective acceptance of ideas* or *reticent participant in collaborative knowledge building.*

pressure and humour to encourage participation when it is needed, he makes the boys laugh during Extract A8 and this seems to bring the boys back to collaborative group work. Hogan (1999) identified positive roles that students can adopt when they work in small groups: *promoter of reflection, contributor of content knowledge, mediator of group ideas or interactions.* In the extracts above, Dale at certain times plays out these roles within the group and will act in different roles depending upon the needs of the group. Dale demonstrates skills in mediating group interactions and is central to the success of this group; he can use humour to help the group to work together. It is worth noting that the group will accept Dale's contributions when he is helping them to maintain a positive group atmosphere but when his contributions to the discussion aim to promote understanding or content knowledge his contributions are often overlooked as in Extract A2, where Dale attempts to start the group rule but is immediately interrupted by Sam.

The others in the group also adopt specific roles; Stephen most often *initiates* the group discussion and when it is necessary will act as a *promoter of reflection.* Liam's role within the group appears to be as a *contributor of content knowledge*, during the group discussion he will often interject facts that are not being discussed. Within the group he most often *extends* what the group are talking about, mainly when he is contributing content knowledge. Sam's role is as the attempted manager of the group. He tries to organise them to complete the task and *elicits* information from the others on occasions.

- The collaborative nature of the boys' group work.

The boys, from the start of their group work together, all, at some time, use the term *'we'* to describe themselves as a group. Throughout the transcripts the group use inclusive terms (*we're, ours*) on forty-three separate occasions (using *I* or *me* thirty six times). Argyle (1969) has noted that the use of these words in classroom talk can indicate increasing group cohesiveness. The boys will also have a developing group history as they gain more

experience working together, this is the *joint activity* aspect of their *common knowledge* (Mercer 2000).

Arvaja (2002) would describe this group as showing aspects of a *tutoring* type of group, there is evidence to show that the group share their ideas and understanding together, Liam who is the more knowledgeable member of the group does share his ideas with the others. The group is highly task focussed in that during the group discussion they do spend most of their time talking about their work; Table 4.1 shows that 33% of time is spent in off task talk or quiet, Geerligs (1995) argues that this is often the case when students are working together co-operatively. The group is involved in *collaborative thinking,* and act as a *community of learners* (Rogoff 1995) as the task is perceived as a shared, common goal and in working towards this they are interested in each others thoughts and they are engaged in *exploratory talk.* This group work together in a similar way to the *work group* defined by Argyle (1969); their role is to carry out the task, group cohesiveness in an important feature and they stop the activity to talk socially.

This group works together co-operatively and successfully move on from procedural and social conflict to work through the tasks set by the teacher as a group.

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Group B

The group discussion explored in this section is that carried out over the four activities by the mixed sex group of two girls and two boys; Robert, David, Cassie and Sarah. The students chose this group for themselves and so they can also be considered to be a friendship group. All of the students sit together in tutor time and in many of their other lessons. During break and lunchtime they are also all together, with other friends. They are a friendly group of students who do not appear to fall out with each other; they also see each other out of school at the local youth club.

In this section, the following aspects of Group B will be described: how talk is used by the group to support learning in science. The way in which this group discuss scientific ideas: the individual nature of the group. I will show that this group appears to approach the task and their development of scientific understanding as individuals rather than as a group. Off–task talk and its role in science group work will be discussed. I also explore the percentage of individual's contribution to the group discussion across the four activities; and particularly the role of Sarah and the contribution that she makes to the group discussion. Next the discussion moves on to the social roles demonstrated by the students during the group work. Finally the collaborative nature of this group's work is examined.

- How talk is used by the group to support learning in science.

The data that follows will show that there are two types of talk used by the group to support their learning in science. Firstly, technical talk is used by the group to organise themselves and to discuss the colours observed from their practical activities. This is the most frequent way in which this group talk about work (Table 4.1 shows 19% of the total talk time). Cumulative talk is used by the group mainly during Activity 4 where the group review their existing ideas about science; this is the only talk taking place over the four activities where scientific ideas are discussed. Cumulative talk accounts for 13% of the total talk time.

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At the start of Activity 1, (described in Chapter 3) the group have completed the practical activity and they are talking about their observations. The group have been told to look at their U.I. paper and start to develop a summary sentence to explain what colour U.I. paper changes in acids and alkalis. As the following extract shows, this group are still carrying out the practical activity. They are using technical talk here to carry out the task and to discuss their results. This technical talk does not develop into cumulative talk because, although they are making observations, they are not responding to each other and therefore the knowledge is not accumulating through the group talk.

Extract B1

Cassie	*It's gone green*	Cassie observes that one of the samples has changed the U.I. paper green.
David	*Sleep for my sheep.*	David is singing and does not respond to Cassie.
Robert	*Sarah should we put in this dip stick, or whatever it is?*	David is still singing. Robert asks Sarah what to do. He does not use the technical term for the U.I. paper, he uses everyday language.
David	*Sarah, it's not the one at the end! That's closest to it! Yea, yours has gone all different colours now, you'll never tell!*	David and Sarah are looking at the pH chart and deciding which colour is closest to the paper. David notes that the samples have changed colour and so now it will be difficult to read the results.
Cassie	*Ah, Sarah, look ours has got a yellow outline, look at that, doesn't that look smart Sarah? Spit on it and*	Cassie is also looking at the results. She notes that the paper is yellow around the edges, probably where the chemical has not touched the paper and so it has remained unchanged. She suggests

make it go all green, or it will probably go tsssssssss! You'd better not.		changing the paper green by spitting on it. Cassie decides not to do this! She demonstrates her conceptual knowledge here that saliva is slightly alkaline.

From the extract, it can be seen that Robert uses technical talk to work through the task. The group briefly talk about colours, what is interesting to note here is that the group are talking about their work, but they do not appear to be responding to each other. There is no evidence of collaboration in this talk, they make observations to which no one responds and so the talk seems to serve no purpose for the group. This talk may support their learning, as it is through their interaction with the task and using their process skills to collect the data, that they can then use this to develop their own conceptual understanding in science, but this is as individuals and not as a group. As they do not engage in collaborative talk this extract cannot be categorised as described in Chapter 3.

This next extract shows how the group can use technical talk to get started on their work; at the start of Activity 3, (as described in Chapter 3) the group have been given a focus for their group discussion by me. My learning objective for the lesson was for each small group to review one section of the whole of the topic. The group have available to them some textbooks, a large piece of paper and one pen. Group B have been told that their poster must contain as much information as they can about metals and non-metals.

Extract B2

Teacher	*Differences between metals and non-metals*	I tell the group what to talk about and leaves them to talk about this and write down their ideas on the poster.

David	*C'mon*	David is waiting for the others in the group to tell him what to write.
Robert	*Shut up I'm looking in the book.*	Robert does not want to be rushed and tells David that he is looking in the book. Robert seems to be using the book given to them by me rather than thinking about what he knows already.
David	*Tell me what to write then quick!*	David is keen to get the ideas down and tells them to hurry up.
Robert	*It says . . . good insulator . . . good conductor.*	Robert, looking at the book, shares some key terms with the group.
Sarah	*What does that say?*	Sarah asks David what something says on the poster.
Robert	*Metals and non-metals . . .metals conduct electricity. How are we supposed to read that?*	Robert reads it out and goes on to suggest an idea. He seems concerned about whether they will be able to read David's writing.
Sarah	*I can!*	Sarah supports David.
Robert	*You can read it out then because I can't read it!!*	Robert suggests that she reads their facts from the poster during the feedback to the whole class.
Sarah	*Conducts electricity!*	Sarah again reads from the poster.

Silence follows for 6 seconds

David	*Divide the page in half*	David suggests that they section the poster.
Robert	*Why?*	Robert is unclear about the reasons for this.
David	*Then metals one colour . . .anyone got a rubber? Doesn't matter it's in pencil crayon. C'mon tell me what to write.*	David says that they can use one colour for their ideas about metals and a different colour for non-metals. He tries to sort this out and asks the group for more ideas.
Robert	*I've already given you one.*	Robert wants someone else in the group to think of a fact.

Here the group have used technical talk to get their work started, they have assumed roles; David is writing on the poster and the others are providing their ideas, Robert is looking in the textbook and Sarah appears to be checking what David is writing. It is interesting to note that Cassie has not made a contribution to this discussion, as Table 4.4 will show later Cassie makes very little contribution to the group talk during Activity 3 (7%). Robert contributes the content knowledge here, David has taken responsibility for writing down the group ideas, and Sarah and Robert are both checking what David is writing down. Robert is fairly insistent that he cannot read what David is written, he keeps returning to this after this extract. One possible explanation for this, is that it is an attempt to annoy David, from the group poster collected in at the end of the activity David's writing is untidy, but perfectly legible, and there is no way that Robert could not read it. From my knowledge of Robert and David this *teasing* is not unusual, and although they are best friends this is a familiar way in which Robert will attempt to draw David into off task behaviour and then hope that David will get the blame. In this instance, this does not work and the group are working together to complete the task set by me; with the exception of Cassie who makes little contribution when the group talk about their work (extracts that follow show that Cassie makes lots of contributions to off task

talk). Now that the group have decided what they are going to do, they go on to complete their poster to share with the class. The field notes show that although the group started this activity well they did become distracted after six minutes, Cassie actually left the group at this point and had to be asked to return to her seat. Their poster did show a good coverage of the key ideas and so it is possible that they became distracted once they felt they had completed their poster in enough detail.

The group, when they are working through Activity 3, spend far more time talking about work than they do during Activity 1 and 2 (Table 4.1 shows 38% of time talking about work compared to the average figure of 32% for all activities). This technical talk at the start of the activity has helped them to get organised and now they manage to stay on task and talk about their work for a longer period of time. At the start of Activity 1 and 2 the group are engaged in social talk and so do not get down to work as quickly, Table 4.1 shows that 50% of the time during Activity 1 and 2 the group are involved in off task social talk.

In the following extracts (B3 to B5), the group has just completed Activity 1 (as described in Chapter 3). These extracts show that the group do not discuss their ideas collaboratively but seem to work as individuals in science during investigative activities. Their talk does not help them to develop their ideas as a group, but interaction with the task is seen to help them as an individual. Within the following extracts there is evidence of how the students work together to construct a rule, in order to report it back to the class. It is interesting to note that the student who knows the rule does not seem interested in helping the others to develop their understanding.

This first extract, follows a period of social talk by the group after they have completed the practical task. David is teasing Robert about girls, this is drawn to a close when Robert brings the group attention back to the observations the group have made. This extract shows Robert bringing the group back to talk about the colours they have observed.

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Extract B3

Robert	*I do know.* *How come yours* *has gone yellow?*	Referring back to the previous conversation about girls. Robert then starts to discuss the colours of the U.I. paper asking for clarification why one of the pieces of paper is yellow.
Sarah	*Cos that's the colour of the paper.*	Sarah explains that this is just an unchanged piece of U.I. paper.
Robert	*There's acid on the table here.*	Robert does not respond to this and notices that there is acid spilt on the table. He does not suggest that this is cleared up.
David	*Look at the other side of it.*	David's attention is also drawn to this yellow paper Robert mentioned before and he draws the group's attention back to it.
Robert	*Oh, does it stick?* *Ours has got all water . . .*	Robert asks if the paper is sticky. He points out to the others that he has a piece of paper with water on it.
Cassie	*Should I get a bit of paper?*	Cassie offers to clean up the spillage off the table. She uses the word *paper* for paper towel.
Robert	*Cassie it'll burn the paper towel.* *Bop . . .bop . . .* *David you've knocked off one of your pieces of that little paper with the acid on it.*	Robert seems concerned that acids are corrosive that it will burn through the paper towel, although as he then sings this could indicate that he is not that worried. He also draws David's attention to a piece of U.I. paper that he has knocked on to the table.

David	*There's two there . . . there's two there!*	David in an unconcerned tone points out that it is actually two pieces.

Interesting points to note here are that, although Robert notices that there is acid on the table though he makes no suggestion to clear it up and make the work area safe. Both Robert and Sarah demonstrate factual knowledge here: Sarah that the U. I. paper is yellow and that it will not change colour unless it comes into contact with one of the substances and Robert when he shares with the group that they are not working safely as there is acid on the table. He also shows later, awareness that acidic substances are corrosive; Cassie offers to clear up the spilt acid and Robert suggests that it might burn the paper towel. This demonstrates Robert's ability to apply his conceptual knowledge, on different occasions, that acidic substances are corrosive. He also draws attention to David knocking one of the pieces of U. I. Paper on to the table. This is the second reference that Robert has made to the working practice of the group; on neither of those occasions does Robert suggest any ways that the group may improve their practice. It is Cassie, a girl, who actually clears the acid away, this may be because Robert, as a boy, does not feel responsible for clearing up and one possible explanation for Cassie clearing away is that it is a more typical role for a girl. The talk then switches to social talk where the conversation continues about what the group do in the evenings.

Robert seemingly acts as the group leader here, as the group discuss their observations when Robert leads it and then he moves the group into a period of social talk. There is little collaborative discussion in the above extract and as Hogan (1999) noted with mixed sex groups there is little knowledge building. The group do talk about their observations and working practice but they do not use this to contribute to their summary sentence, indeed they have not even talked about this as the aim of their discussion. Their talk does not seem to serve the purpose of completing the task set by me.

Later on, during the activity after a period of off task talk, the group return to discussing their observations:

Extract B4

Robert	*Go on and dip some more of that stuff on it to make it blue! David you knocked that piece of paper off it!! That's ours, oh yea what thing! Have you made them go blue?*	Robert is telling Cassie to change all of the pieces of U.I. paper blue by adding alkali, sodium hydroxide solution to all of the watch glasses. He uses everyday language to describe the solution calling it *that stuff*. Robert makes sure that Cassie has changed all of the group's pieces of U.I. paper blue. He again makes reference to David knocking pieces of U.I. paper on to the table.
Cassie	*Yea!*	Cassie (laughing) lets Robert know that she has successfully changed all of the samples blue.
Robert	*Good girl . . . now they're all gonna go blue.*	Robert congratulates Cassie and laughing says that all the samples are now blue.
Sarah	*I told you you had it! I told you you had it!*	Sarah points out to Robert and Cassie that they have one of her samples. Her tone is exasperated, possibly because Cassie has now changed the sample blue.
Robert	*Dish . . .why have I got seven? Oh no we got six ain't we?*	Robert confirms that they have seven samples and that they should only have six so he and Cassie must have one of Sarah and David's samples.
Cassie	*No don't burn my*	Robert now puts Cassie's pencil into one

	pencil, I suck that!	of the samples. Cassie, in a concerned tone points out to Robert that she puts her pencil in her mouth.
David	*Robert, Robert!*	David tries to get Robert to stop this, possibly because he is putting the pencil into one of David's samples now that his own are all blue.
Cassie	*It might kill me!*	Cassie is aware that acid is dangerous and that it is not a good idea to put it in her mouth.
Robert	*Cassie*	Robert starts to respond but is interrupted by me giving an instruction to the whole class.
Teacher	*One minute to come up with a rule.*	
(To class)		

As the extract indicates, Robert demonstrates conceptual knowledge here, in that he is aware of how to change the U. I. paper blue; he knows what chemical to add although he does not use the name of the chemical. No one in the group challenges Robert's behaviour even though it is changing their results. It is interesting to note that Robert does not sabotage the results himself but he gets Cassie to do it for him, this is fairly typical of Robert. It is similar to the extract above where he attempted to lead David off task; here he manages to ensure that Cassie is off task and if the teacher notices this Robert may appear not to be doing anything wrong although the talk shows that Robert has instigated this. Sarah appears to be able to remain on task, despite the distractions of Robert and Cassie. This would appear to support the view of Arvaja et al (2002) that girls can remain on task in mixed sex groups although it is interesting to note that Cassie does not remain on task and is distracted by Robert. Richmond and Striley's (1996)

roles, which can be recognised when students work in small groups, can be used to examine the relationships in the group; Robert is acting as a persuasive leader in that he remains unchallenged by his peers, Sarah is acting as a helper in that she is trying to help the group to complete the task and both David and Cassie are active non-contributors in that they are not moving the group on at all in the task. Hogan (1999) would describe Robert, David and Cassie's roles as *promoters of distraction.* They are not moving the group on in the task in any way. The group, as they have changed all of the pieces of U.I. paper blue, will now have difficulty using their observations to develop their summary sentence about the role of U. I. paper.

Following on from my comment that there is now only one minute to develop the sentence, is the following extract. Up until that point the group have not attempted to discuss their group rule in any way at all although they have made comments about their observations of colours. Any talk about work has been of the type shown above, interspersed with social talk and about the colours observed, with no reference to the pH scale at all.

Extract B5

David	*We've made ours . . .no we haven't. Yea?*	David responds to the my comment confirming that he is aware of what is expected of the group. He *initiates* (Barnes & Todd 1977)the group talk.
Cassie	*You have to be careful not to use too much acid.*	Cassie shares a suggested rule with the group. This refers back to the talk about spilt acid in Extract B3. No one responds to her even though she is trying to talk about the group results.
David	*Robert . . .* *Robert . . .* *don't!*	Robert distracts this talk by altering the colours of U. I. paper by adding chemical to Sarah's and David's

		samples. David asks Robert not to do this, he is trying to look at the results.
Robert	*Don't what?*	Robert plays innocent and asks David what he would like him to stop.
Robert	*Sarah leave our acid alone!*	Sarah has started to alter Robert's and Cassie's results. She is trying to correct them after Cassie changed them all blue (Extract B4).
Cassie	*Noooooooo!*	Cassie calls out in an attempt to stop Sarah altering her results.
David	*We don't want it blue!*	David again tells Robert to stop. He is trying to change all of the samples blue.
Sarah	*That's because that is a blue one!*	Sarah reassures David that it is ok. That sample should be blue so it must be an alkali. This implies Sarah's conceptual knowledge about U. I. paper. and the fact that it is blue in alkali.
Robert	*Oh Sarah . . you're making it drip!*	Robert draws Sarah's attention to drips on the table. Robert seems very concerned about this (he has made references of this sort in Extract B3 and B4)
Cassie	*Get off my person!*	Someone has got hold of Cassie presumably to try and stop her altering the results. My attention has been drawn to the group who field notes show are of task.
Teacher	*Okay. Stop! Stop!*	I join the group and ask them to stop what they are doing.
David	*Miss they've wrecked*	David tries to explain what Robert and

	theirs they've put ink in it and everything!	Cassie have done to the results. He tells me that they have ink in them. He is referring to the fact that they have changed all the samples blue.
Teacher (to class)	*I want each group to come up with a sentence that describes their rule. Each group must come up with a sentence for their rule!*	I go on now to give an instruction to the class. I am stood with this group. I clarify the task for this group and the whole class.
David	*Yea*	David confirms that he knows what he is doing.
Robert	*Miss can you come and help us what do you mean by rule?*	Robert calls me over to the group to clarify the task. He does use the word *us*.
Teacher	*When you test acids the colour is . . .*	I go on to give the first part of a possible sentence to help them, to scaffold the task to help them to complete it.
Robert	*red . . . and the alkalis are blue!*	Robert immediately completes the sentence, demonstrating his conceptual knowledge about the role of U.I. paper. He has not previously shared this with the group.
Cassie	*Ours is multicoloured!*	Cassie seems still to be unclear what her results show which is unsurprising considering the amount of sabotage that has been going on with these results.
Robert	*because Cassie put*	Robert tries to blame Cassie for the mess

	about 12 pieces in!	he directs this comment at me. Possibly to get Cassie into trouble. Robert demonstrates procedural understanding here that because they have messed with the results so much they cannot be used to develop a conclusion.
Teacher	*Just work in your group!*	I ignore him and ask the group to work together.
Robert	*Don't worry about it!*	Robert replies, he seems irritated that Cassie did not get into trouble.
David	*Finished my sentence!*	David, working as an individual shares that he has finished his sentence.
Cassie	*It goes blue or purple?*	Cassie is still unsure and asks the group to help her. There is evidence here of Cassie's procedural understanding, she goes back to the results to develop her summary sentence.
Robert	*Green*	Robert tells her a colour but does not explain further.
Cassie	*Ah!*	Cassie responds seeming to accept his answer at face value.
Robert	*David, don't put ink on the table!*	Robert again draws the group's attention to something on the table and is keen to blame David.
David	*Look yours has gone blue!*	David is again making reference to to one of the watch glasses.

Cassie	*I put too much thingy in it!*	Cassie explains this by saying that she added too much chemical.
Robert	*What colour should it go?*	Robert attempts to clarify the blue observation.
Cassie	*Purple*	Cassie replies with any colour.
David	*Red*	David suggests that the sample was an acid and would change the U.I. paper red.
Sarah	*Was that with the acids?*	Sarah asks the group if that sample was an acid.
David	*Alkalis go green and acids go red! If there's somebody . . .*	David shares his summary sentence with the group and then starts to sing.
Cassie	*It doesn't go red at all it goes purple!*	Cassie is still confused about the colour that is observed.

After this extract, no one responds to Cassie and they do not help her to clarify the colour observed. Social talk follows and Cassie is left to develop her own conclusion about the results.

It is interesting to note that during the extract, both David and Robert call the teacher over to help them and do not ask the rest of the group for help. She (1999) notes that this is a typical behaviour of boys when they work in

mixed sex groups. Robert takes responsibility for the group when he uses the word *'us'* when asking the teacher for help. The extract provides further evidence for an observation that the group work as individuals to develop their own conceptual understanding from the results of the practical activity, Robert and David share their own rule with the group. This supports Murphy (1998) who has also noted that often, in mixed sex groups, boys choose to work independently. In this activity, Sarah makes the lowest level of contributions to the group talk and all of her contributions are work related; Sarah seems able to stay on task while the rest of her group exhibit variable ability to get on with the task set by the teacher, this is a characteristic of girls working in mixed sex groups as noted by Arvaja et al (2002).

Here individuals in the group can be seen to demonstrate that through the practical activity or previous experience that know that U. I. Paper is red in acids and blue in alkali. In the talk, there is evidence of them using the process skills of observing and collecting evidence but they do not talk together about their procedural or conceptual understanding about U. I. paper. Robert, during the extract, states the rule after talking with me but David also shows some knowledge by his statement at the end of the extract. Sarah also demonstrates in the extract that is aware that U. I. Paper is red in acids. There is evidence that Cassie knows that one of the samples changed the U. I. Paper purple but there is nothing to suggest that she has linked this with either acidic or alkaline substances. Here the talk is about the construction of a summary sentence which each of the students is working on individually, interestingly once Robert has stated his sentence he takes no further part in discussion that would help the others. He does ask questions of the others but makes no response about whether they are right or wrong answers, in his opinion.

Individuals in the group do develop their conceptual understanding in science through carrying out the practical investigation. There is no evidence to suggest that the talk helps them in any way. Collaborative talk

does not develop in this group as they appear to be unable or unwilling to share their cognitive resources with each other (Hennessy and Murphy 1999). There is no evidence to suggest that the group possess the skills to carry out collaborative talk, or they may not be motivated to do so. One possible explanation for this is that there is no innate awareness of Mercer's (2000) ground rules for exploratory talk (Wegerif 2002) in this group. They do not share their ideas in a way that allows them to develop their scientific understanding. Instead of collaborating with each other, the boys call me over to help, and it is with me that Robert shares his rule. The group do not even collaborate to check their ideas with each other, they seem very concerned with completing the task and less so about the quality of their contributions. The data from this activity shows that the group do not talk about who is sharing their group rule with the class, field notes detail David feeding back their group rule to the class with the others interjecting their ideas.

This investigative science activity does not generate sustained cumulative talk, where knowledge is shared and accumulates to any great extent in this group. This is also found during Activity 2, where the quantitative data (Table 4.1) shows that there is no cumulative talk at all; this investigative science activity did not bring about any discussion of scientific ideas. There are several possible explanations for this: the task may be so simple that they do not need to talk about it, if this were the case they may not be motivated to share their ideas. As individuals, they may not have the social skills to talk collaboratively, they may need to be taught these as Mercer (2000) suggests. The group, do not appear to use their *common knowledge* in their talk; they talk about the colours observed but not their procedures or what the colours mean. There is no evidence that they have used the pH scale during this activity. The group have a tendency to use their own words when they talk about science; the extract shows they use few technical science terms in their talk. Cumulative talk does not develop during investigative science for this group. The next extract demonstrates cumulative talk as it happens in this group.

Cumulative talk is seen to increase in Activity 3 and 4 (Table 4.1). The cumulative talk from Activity 4 will now be examined to show how this group do talk about their ideas in science. In the following extract, there is a good example here of discussion of scientific ideas between Robert and Sarah; Cassie tries to distract the group's attention in this activity. In Activity 4, the group have been given a set of questions by the teacher and they are using these to prompt a review of the topic and discussion about the key scientific ideas covered. The group have been given the set of questions by the teacher and Sarah has them.

Extract B6

Sarah	*Solids, liquids and gases how are they different?*	This is the first question read out by Sarah from the cards. The group are being asked to think about the differences between solids, liquids and gases.
Cassie	*They're all different things.*	Cassie without explanation says that they are all different things. This may indicate her own understanding of the topic or she may be being silly and answering the question in a very simple way.
Robert	*Yea . . . there you go!*	Robert agrees with this very simple and non-scientific answer. Sarah takes this as a cue to move on.
Sarah	*What is condensing? When all the stuff that's been evaporated goes onto something cold and it all . . .*	Sarah is reading from the second card. She answers the question herself.

Robert	*and it condensates!!*	Robert completes Sarah's sentence for her. Sarah takes this as her cue to move on.
Sarah	*How do the particles move in a solid? We had that one before.*	Sarah reads from the third card, although. she thinks they have had this before.
Robert	*They are jam packed again.*	Robert answer shows he is thinking about how the particles are arranged when they have been asked about how they move. Robert uses everyday language to describe this.
Sarah	*and they don't move.*	Sarah extends Robert's answer to include an observation about movement of particles. She also uses everyday language, the students have been introduced to the term vibrate.
Robert	*Liquid point three in a gas they party . . .*	Robert uses his own words to describe the movement of particles in liquids and gas.
Sarah	*What is the distance between the particles in solids, liquids and gases?*	Sarah reads the fourth question from the card.
Robert	*I haven't got a . . .*	Robert starts to say that he does not know when David interrupts him.
David	*Nothin . . .*	David's answer may imply that the particles in a solid are very close together, again he uses everyday language.

Sarah	*In solids they're really together . . . in a liquid they're . . .*	Sarah clarifies this sharing with the group that she is talking about solids, she also uses everyday language to describe the distance.
Robert	*Spread out!*	Robert interrupts and shouts his answer excitedly.
Cassie	*Don't get too excited!*	Cassie makes reference to Robert's enthusiasm. She warns Robert about joining in the activity too much.
Robert	*In a gas they just wooooooooo!*	Robert, equally as enthusiastically, goes on to share his ideas about the particles in a gas. He makes a noise to represent them whizzing around. He does not use scientific terms.
Sarah	*We've already had these! These are our original ones.*	Sarah is back to the start of the questions and so the group have completed the task set by the teacher.

What is interesting to note here, is that Sarah and Robert are working together and that they are using everyday language to answer scientific questions. They are engaged in cumulative talk, structured by the questions, as scientific knowledge is accumulating as the conversation continues. Here it can be seen that Sarah seems to be regulating the discussion, possibly because she has the questions. However, nobody challenges this, and it is interesting to note that Robert allows her to lead the discussion. David acts in a way that has similarities with a *reticent participant* (Table 4.4 shows that David unusually says very little during this activity) and Cassie is a little more active in attempting to distract the group, her attempt at becoming a *promoter of distraction* (Hogan 1999) possibly fails because no-one joins in with her. She draws Robert's attention to the fact that he is answering the questions in an excited way. Sarah is a persuasive leader, in

that she will not negotiate and she does not attempt to include all of the individuals in the group. Analysis of the group using Hogan's (1999) roles could observe that here Sarah and Robert are acting as *contributors of content knowledge* and Cassie and David could be described as *reticent participants in collaborative knowledge building*. There is evidence here, in this mixed sex group, of knowledge building although it is only Sarah and Robert who are participating in it. By the end of Activity 4, Sarah has increased her participation in the group.

There is evidence to show that Robert and Sarah engage in collaborative, cumulative talk where they extend each others ideas and knowledge builds through their conversation; David and Cassie do not involve themselves in this type of talk so it cannot be said that cumulative talk is used by the group, as not all of the individuals take part. In investigative science activities the group appear to work as individuals where they will ask the teacher for help rather than ask each other. When the task is more structured, in this case by the questions, cumulative talk seems to develop.

Social talk is the main type of talk for this group averaging at 40% of the total talk time (Table 4.1) and it is the purpose for this in the group that I now go on to explore.

- Off task and social talk and its role in science group work.

Although social talk averages at 40% (Table 4.1); the data shows that over the four activities it decreases. The investigative science activities giving high values (averaging at 50% for these activities), with the more structured activities 3 and 4, averaging at 30%. Exploring this talk will provide an insight into adolescents working together, in mixed sex groups, in the classroom, their social relationships, and whether this social talk has any role in learning or the building of group cohesiveness. This following extract would suggest that, for this group, social talk does not have a role in learning or the building of a positive group to support learning. It is taken from the discussion of Robert, David, Cassie and Sarah during Activity 1

and is an example of talk that is completely unrelated to the task and distracts the group from their work.

Here the group have completed the practical task and should be discussing a group rule that describes U. I. paper and what colour it changes in acidic, neutral and alkaline substances. Robert, David and Sarah have all written their own individual rule in their own books without group collaboration; Cassie is still unclear about what she should have observed, Extract B5 shows her to be confused about the colours. At this stage they have no group rule and have not elected a member of the group to share their observations with the rest of the class.

Extract B7

David	*Guess how much money I've got today?*	David leads the group in this social talk. He interrupts Cassie and Robert who had been talking about the colours that the U. I. paper had changed (the end of Extract 5)
Cassie	*Nothing!*	Cassie is immediately distracted from the talk about colours and joins in with David.
David	*Two pound thirty! That's all! That's one hour's work.*	
Robert	*Two quid thirty!*	
Sarah	*Yea but it . . .*	Sarah's comment does not follow on from David so it is likely that Sarah's comment relates to the previous talk about colours.
David	*Two quid thirty though! Two pound*	

thirty I've got a quid

off Cassie because

Cassie loves me don't

you darling!

This talk has no relevance to the task and from this point onwards the group continue with social chat until I bring the small group discussion to a close, no group rule is resolved. What is important to note here, is that the group seem unconcerned that they have nothing to share with the class and that it is my intervention that brings the group back to task and stops the social talk. David here acts in the role as a *promoter of distraction* (Hogan 1999) in that he completely lead the group away from their previous talk about their work. Cassie also allows herself to be drawn in to this despite the fact that it interrupted her trying to clarify her results. Sarah does not join in and this often happens in this group talk. During this activity Sarah's total contribution is 4% (Table 4.4) and all her contributions are work related.

The following extract, comes from the group working on Activity 2 (as described in Chapter 3). The extract that follows is typical of the talk found with this group and is purely social chat about issues that concern them as teenagers; football and going out. The group spend 52% (Table 4.1) of this activity engaged in social talk. The group do not complete this activity successfully; they do not develop a group rule about the role of litmus paper and only spend 15% (Table 4.1) of their time talking about the colours they observe. They talk about the observations, but not about what they might mean, they make no attempt to discuss their group rule together.

Extract B8

Robert *You should have*

come to the Ice

House last night man!

Cassie *Yea, but the thingy was*

cancelled so I didn't

. . . Telford

Robert *Did you?*

David *That was crap*

Robert *What was the score*
about 18 million nil
to them

Cassie *To Telford*

Robert *No, the other team lost*
because they beat
Leeds didn't they

David *Telford lost 16*
million nil wannit!

Cassie *I left at half time*
. . . I was freezing!

David *It wasn't it was*
warm if you got in
the stands. Cos I
had a big burger
. . .like that . . .
that big . . .

Cassie *Which stands were*
you in?

Teacher *One minute and fifteen*
(to class) *seconds have gone*
of your five minutes.

David	*The entrance is there . . . yea . . . and this stand here. What?*	The group continue their conversation as if they had not heard the me and yet on. the tape my voice is clearly heard.
Cassie	*We were there, then we were there . . . then we were there then we were there then we were there . . .*	
David	*Then you were in the car?*	
Cassie	*Yea!*	
Robert	*Then she was in the house!*	
David	*What score was it?*	
Cassie	*What?*	
David	*What score was it when you went?*	
Cassie	*4-1*	
David	*Who to?*	
Cassie	*Them.*	
David	*Do you know what the score was in the end? . . . 8-2, no 6 or 7-2.*	
Robert	*Telford actually won!*	

	Anyway what are we supposed to be talking about?	
David	*Foooood!*	
Robert	*Oooh doughnuts!*	
David	*McChicken roll!*	
Robert	*Do your work then!*	Robert is clearly aware that they should be working and draws a close to the social talk.
David	*What's the rule then?*	David immediately asks Robert to tell him the conclusion.

The extract finishes with David asking what the rule is, to which no one responds. Several issues are of interest to note here; firstly, Sarah takes no part in this type of discussion at all. The group do not respond in any way to my comment that over one minute of the discussion time has elapsed. Robert is aware that the group are not discussing their work, draws attention to this and then joins in more off task talk. Again Robert brings the group attention back to the fact that they are not working when he says, *'Do your work then'*, to which David responds by asking the group what the rule is as if it is something that can just be decided without any discussion.

The extracts above are typical of the social talk taking place in this group, this social talk does not make any contribution to the learning in this science lesson and it is important that teachers are aware of this when monitoring group work.

- The individual's contribution to the group discussion across the four activities.

The table below details the individual's contributions as a percentage of total talk time and across the activities.

Table 4.4

% talk of students	Activity 1	Activity 2	Activity 3	Activity 4	Average
Robert	37 (50)	26 (18)	37 (44)	42 (46)	35
David	34 (46)	43 (30)	35 (40)	2 (2)	29
Cassie	25 (33)	28 (19)	7 (8)	20 (22)	20
Sarah	4 (6)	3 (2)	21 (24)	36 (40)	16

( ) Figures in brackets are the number of interactions for each student.

From the data it can be observed that Robert's contributions to the group discussion remain similar and he always talks the most except during Activity 2, from the extracts it can be seen that Robert will join in any type of talk, whether it is about work or off task. David's contributions are similarly high except in the last activity where he arrived late, David, as the extracts show, makes little contribution to talk about work. During Activity 3, extract B10, all of the others members of the group contribute an idea to the group poster; David is writing and so does not contribute an idea here. Most often David's contribution is off task talk, as the extracts show. Cassie's contributions are fairly constant, except Activity 3, Cassie's contributions are often off task and as the off task talk decreases across the tasks so does Cassie's contribution to the group talk. Sarah's contributions increase in the final two activities; this is coincidental with the increase in time talking about work, that is, when the group are engaged in cumulative or technical talk (Table 4.1). Sarah's contributions increase as the time that the group spend engaged in cumulative talk increases. Her contributions are

low when the group are mainly involved in off task social talk, in which she does not take part as the extracts show. There is a difference here between the contributions of the boys and girls in this mixed sex group, the boys do dominate the group talk. This supports the view taken by Swann 1992 and She 1999.

- The social roles demonstrated by the students during the group discussion.

The data in the table below is a tally of the social roles adopted by the group over the course of the activities:

Table 4.5

Social role adopted by student.	Robert	David	Cassic	Sarah
Promoter of reflection	3			1
Contributor of content knowledge	13	1	1	10
Mediator of group interactions		1		
Promoter of acrimony				
Promoter of distraction	13	8	7	
Promoter of simple task completion	2	1	1	
Reticent participant in collaborative knowledge building		1	2	

Robert started, as the group leader, in the first two activities. He led the group in the discussion about work and he also led the group in to social chat and off task behaviour. His main roles in the group were as a *promoter of distraction* and as a *contributor of content knowledge*. He can promote reflection back to the task as shown in the extract from Activity 3 above and on occasion he will complete the task in a simple way rather than talk about

his ideas, as shown in Extract B6. Robert, once he was aware he had completed the activity made little contribution to the learning of others, during Extract B5 where he shares his conclusion with me but does not appear to be interested in helping Cassie. One possible explanation for the way the group talk differed, over the activities, may be that it depended on whether Robert was in the mood for work or not. In my knowledge of him as his form tutor, this would be a justified explanation, Robert does tend to work when he wants to and on the type of activities he wants to. Robert is not a keen practical scientist preferring other types of activities, he does enjoy role play activity and debating where he can talk but he is more able to use his imagination. Robert appears to need Sarah to prompt him to join in *cumulative talk.*

David most often acted as a *promoter of distraction* (Hogan 1999). He was reluctant to take part in collaborative learning, making few contributions to increase content knowledge although he was happy to take a lead role in writing the group ideas down during Activity 3. During extract B10, David asks the others for ideas, one possible explanation for this is that he may feel that by writing the ideas down, this is his contribution to the group work. David may also feel that this is an easier option than thinking. This would fit well with my understanding of David, he loves to talk and will talk to anybody about anything, but preferably football, he can be easily distracted and needs others to guide him to complete tasks on time. David is not mature enough to self regulate his talk and keep himself on task; he likes to be the centre of attention and to have the last word. David is keen on carrying out practical work but approaches the follow up work to this with reluctance. He was happy to chat socially as extract B8 shows, but did not lead this; he could easily be drawn in to this type of discussion and silly behaviour by Robert and Cassie.

Cassie did not have a clearly defined role, although often she was involved in social chat and off task behaviour. She did try to contribute to the knowledge building discussion in the group but was often ignored when she

did this, as in extract B10 where she makes a contribution to the group poster and no one responds to her. When Cassie was experiencing difficulty answering questions no one in the group helped her, as in extract B5. Her main role in the group was as a *promoter of distraction*. One possible explanation for this is that when she is involved in off task talk at least David and Robert talk to her, as in extract B7 and B8.

Sarah's work within the group was always in a role that encouraged collaborative knowledge building, her main role in the group was as a *contributor of content knowledge* (Hogan 1999) and over the course of the activity she became the leader of the group and lead Robert particular into longer periods of *cumulative talk* (Mercer 2000), as extract B6 and B10 show. She started the activities with a very low percentage contribution to the group talk as Table 4.4 shows and over the course of the activities she became one of the main *contributors of content knowledge* in the group. She was one of the two dominant contributors of talk in Activity 4.

In the above extracts the group are showing strong similarities with the description of Argyle's (1969) adolescent group in that the conversation is mainly about peers and social lives. Social acceptance within the group is important for, David, Cassie and Robert; this does not seem to be the case for Sarah. The evidence to support this is that Sarah rarely takes part in the off task talk and does not participate at all in silly talk, as extract B8 shows. On occasion, the discussion in this mixed sex group also has similarities with the observations of Schumck and Lohman (1965) who note that when adolescents work together in groups they can often be involved in silly, infantile behaviour that causes much giggling. One possible reason for this talk developing is that some adolescents do not have the skills to keep themselves on task; they do not appear to be concerned about completing the task and this lack of focus may lead to less purposeful and distracting talk. For this mixed sex group, they do not work as a group to complete the task, they work as individuals and so they do not appear to have a joint goal

that unites them except the features that they have in common in their social lives.

The social roles adopted by the individuals in this group do impact upon the learning in a negative way. Having three *promoters of distraction* in the group does not help them to talk about their work. In this first two activities, Sarah does not lead the group in talk about work, one possible explanation for this is that she is working as an individual to develop her own conclusion and sees little value in talking with the peers. This certainly could be the case if Sarah found the task easy; this mixed sex group's talk seems to be affected by the type of task.

- The collaborative nature of group work.

Collaborative discussion does not develop in this group to include all of the four students. The data shows that, over the course of the activities, Robert and Sarah develop collaborative discussion in the form of cumulative talk; but this is as a pair and not as a group. Social, off task talk can get in the way of collaboration; certainly this group spends the most time in this talk over the activities (Table 4.1). This group need help and support in learning to collaborate (as discussed in Chapter 5) and then hopefully a further intervention by me would help them to engage in collaborative talk and use this to learn in science. Social roles and relationships in the group inhibit their ability to collaborate; there are too many *promoters of distraction* (Hogan 1999) in this group who all join in the off task talk. Different tasks seem to help their collaborative talk (Table 4.1), the more structured by me (as described in Chapter 3) the more they collaborate, Activity 3 and 4 being more structured and directing the students to talk to each other more, leads to an increase in *technical* (Arvaja at el 2002) and *cumulative talk* (Mercer 2000) as shown in Table 4.1.

The next chapter includes a summary of the main findings from these Groups A and B, looking at what this data can offer to teachers in terms of

advice about group work in science and how this may be set up and monitored.

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Chapter 5 Conclusions

The aim of this chapter is to discuss the findings of this research with the purpose of providing advice for practitioners in the classroom. This research project set out to provide a detailed analysis of the ways in which students work together in small groups in the science classroom. An intervention was introduced, where specific scientific tasks were planned with opportunities for the students to talk in their small groups. The aim of this intervention was to encourage the students to talk and share their ideas with each other. The research questions identified at the start of this research were:

- What is the language used by the students when they work together in small groups to complete specific science activities? What are the types of talk that develop and how do these contribute to learning in science?
- How do the groups work together and what is the effect of the social relationships they develop and the social roles they adopt on their talk and learning in science?
- What is the nature of the communities that develop? Do they have similarities with *communities of learners* (Rogoff 1994)? What is the impact of the communities that develop on the talk found in the groups?

The aim of the next part of this chapter is to review the findings of Group A, the group of four boys; Sam, Dale, Liam and Stephen and Group B, the mixed sex group of two girls and two boys; Robert, David, Cassie and Sarah. I then move on to look at the similarities and differences observed between the groups, exploring any differences observed in the talk with a specific focus on social roles and relationships and the impact that they have on this.

These findings will impact upon my own practice and the practice of other teachers and what this research has to offer in terms of advice to teachers

when using small group work in science will be discussed. Inevitably there will be further research questions that still need to be addressed in light of these findings and I will make suggestions about what questions this research still leaves unanswered.

Summary of the Main Findings from Group A.

The data shows several interesting features of the group discussion carried out by Dale, Liam, Sam and Stephen. The intervention could be considered to have been successful with this group, as in total, the percentage of time that the students are engaged in cumulative and exploratory talk is 38% of their group discussion.

Firstly I look at how the boys use talk and the possible purposes that each of the categories of talk serves for them during their work together:

Table 5.1

Type of Talk	**Purpose**
Technical	organising themselves to complete the task
Disputational	used by Sam to summarise group thought when they are under pressure to complete the task
Cumulative	two purposes; to discuss the results from practical activities and to review scientific understanding
Exploratory	conceptual understanding in science is developed
Off task	humour forms a part of this group's working and off task talk is used to resolve the social conflict during Activity 3

From the boys' talk it seems that common knowledge is evident and helps the boys to develop collaborative, exploratory talk. This common knowledge arises as the group have worked through the practical activity together and so have joint experience within which to base their discussion, importantly the boys use their joint experience during the discussion to talk about their ideas together. Working together over time also means that they will have a group history of joint activity. Cohesiveness does develop over the time of the observations, this can be indicated by the fact that they can

resolve social conflict and go on to complete the task set by the teacher after this. The boys do talk about the experiences they have had during previous activities and use this during their discussion, in this there is a sense of collective remembering where the boys do talk about their previous science lessons and the ideas they have discussed within the new context of their current discussion (Extract A3). The boys use the common knowledge they have developed to become successful collaborators in the classroom.

The boys learn in science by using exploratory talk to develop new ideas, one example being their talk about the role of U.I. paper and cumulative talk to discuss scientific evidence and review scientific ideas (Extract A1, A2 A3 and A4). Activities 1 and 2 demonstrate that the boys develop their conceptual knowledge in science using the process skills of observing, asking questions and collecting and interpreting evidence, during this cumulative talk is used. Procedural understanding is shown by Dale and Stephen who both know that the observations need to be used to develop their scientific understanding and that the results must be reliable and generated by following the procedure properly (Extract A1, Extract A4). Conceptual understanding is then developed from this using these observations and exploratory talk. Scaffolding of learning does take place where differential responsibilities are demonstrated by the different social roles adopted by the boys. These different social roles allow the boys to demonstrate differential expertise, for example in Activity 1 where Liam and Stephen act as contributors of content knowledge and Dale acts as a promoter of reflection and it is through these different roles that their scientific understanding develops.

This group can be described as a community of learners, as they learn through their collaboration with each other as they work on the activities of their community. The group work collaboratively across the activities, collaborative moves can be found in the boys' talk and they actively work together to produce a single outcome and share their cognitive resources when they talk together. This collaboration is seen to decrease when

conflict occurs, when in Activity 3 procedural conflict develops into social conflict.

The social roles that the boys adopt is summarised in the table below:

Table 5.2

Student	**Social Roles**
Sam	Only role as a contributor of content knowledge (less often than Liam). During Activity 3 only, Sam acts in the role of promoter of acrimony (when the social conflict is occurring).
Liam	Main contributor of content knowledge in the group (often starts the group off in knowledge building talk). During Activity 3 only, Liam acts in the roles of promoter of distraction and promoter of acrimony (when the social conflict is occurring).
Dale	Promoter of reflection and the only member of the group to act as a mediator of group interactions.
Stephen	Stephen does act as a promoter of reflection and contributor of content knowledge.

The literature suggests that it is through the positive social roles of contributors of content knowledge, promoters of reflection and mediator of group interactions that this group can work together to develop exploratory talk as Extracts A1-A4 show. Dale's role of *mediator of group interactions* (Hogan 1999) becomes important in keeping the group together during and after the social conflict of Activity 3, this is the way in which Dale leads the group. Interestingly, Dale does not show this quality until it becomes necessary; when the group are distracted by the conflict between Liam and Sam from carrying out the task.

The group show similarities with Argyle's (1969) work group in that they do work together to carry out the task and they do break this to engage in

talk of a social nature, this talk can be seen to serve the purpose of bringing about group cohesiveness.

The nature of the task does have an impact on the group talk as it is only Activities 1 and 2 that allow exploratory talk to develop. It would seem that these activities allow the boys to use their process skills and procedural understanding to develop conceptual understanding and they will use exploratory talk to do this. The quantitative data shows that all of the boys spend time contributing to the group talk with no significant difference between them on average and across the tasks.[20]

Comparing this single sex boy group with the gender literature, they show similarities with a single sex girl group in that they are highly collaborative. They also show that they can critically discuss ideas without arguing, this is different from research with single sex boy groups.

Summary of the Main Findings from Group B.

The main findings from the Group B data are now discussed. The intervention introduced has not worked successfully for this group, they spend only 13% of their group discussion engaged in cumulative talk and exploratory talk does not develop at all; the reasons for this need to be explored with a view to provide teachers with advice of what to avoid in the classroom when using small group work as a pedagogical approach. Firstly, I will explore the ways in which Group B use talk and the possible explanations for this:

[20] Student's t-test was used and none of the differences were found to be significant.

Table 5.3

Type of Talk	Purpose
Technical	to organise the group to complete the task; this is the main way in which the group talk about their work.
Disputational	not found
Cumulative	review scientific ideas during Activities 3 and 4
Exploratory	not found
Off task	most of the time the group are talking in this way, talk about their social lives, other students, or the talk is silly in nature seeming to have no meaning at all

From the data the group seem to work in science as individuals. In the transcripts there is evidence that they are using the process skills of observing and collecting evidence but this does not appear to be followed up by any discussion together about their procedural understanding or conceptual understanding about science. They discuss their results together, but then develop their 'group' rule as individuals, after interaction with the task and some checking of their observations with their peers. There is evidence that David, Robert and Sarah all develop their own conclusion but Cassie, in Activity 1, clearly has not and none of the others make any effort to help her by sharing their ideas with her. They will let her copy their ideas though, without any explanation. This has similarities with the other tasks, in that the group will complete the task in a simple way rather than talk about their ideas together. They seem to accept the view of the first person that answers, as in Extract B6, where Cassie answers a question in a very simple way, Robert agrees and the group move on even though there are other possible answers these are not discussed. During Activity 2 they do not discuss their scientific ideas at all and so do not develop a group conclusion about the role of litmus paper as an indicator, they do not use their process skills to develop their procedural understanding. The evidence that learning may not have taken place here is that none of the individuals claim to have written their own rule where as in the previous activity they did and sharing of these rules during the group talk showed evidence of the

students' conceptual understanding. During Activity 2 there is no sharing of their conceptual understanding with their peers.

The social roles adopted by the individuals in this group do have an impact on the learning that is taking place.

Table 5.4

Student	**Social Roles**
Robert	Acts in a number of roles, mainly a promoter of distraction, one of the two main contributors of content knowledge.
David	Mainly a promoter of distraction and a promoter of simple task completion.
Cassie	Mainly a promoter of distraction and a promoter of simple task completion.
Sarah	Her only role is as a contributor of content knowledge.

In this group there is no individual who is consistently acting as a promoter of reflection or as a mediator of group interactions when the group need this to move on. This group lacks any group leader and this could account for the amount of social talk that takes place compared with the talk about work, which takes the forms of mainly technical talk and then cumulative talk. Over time, two of the students in this group adapt to the task by changing their social roles; Robert increases in his contribution of content knowledge, as the task becomes more structured, and Sarah becomes a contributor of content knowledge, as the group start to spend more time talking about their work (or more accurately as Robert and Sarah increase in the amount of time, as a pair, they talk about work).

The group would be classified as a typical adolescent group by Argyle (1969) as their conversation is mainly about their social lives and feelings and they act in a silly way that they all find amusing. It is interesting to note that Sarah does not take part in the social talk but, when she has the

opportunity, spends much of her time talking about work and contributing content knowledge with Robert.

As a group they do not work collaboratively in that they seem very reluctant to share their cognitive resource with each other. They will check their ideas with the teacher rather than going to the rest of the group for advice, both Robert and Sarah do this during Activity 2. Collaboration starts to develop during Activity 3 and 4 but again it is not the entire group who take part in this. It is mainly Robert and Sarah who do work together, to talk in a cumulative way, and in a way that allows them to share their ideas about science (in an uncritical way) and show through their talk that knowledge is accumulating. Collaborative moves are not evident in this talk.

The type of task seemingly has an impact on the talk with this group. Using process skills of the type found in Activities 1 and 2 does not lead to group talk about scientific ideas. Activities 3 and 4 which were structured to a greater extent by the teacher, as shown in Chapter 3, gave a greater increase in cumulative talk, in these activities social talk was found to occur mainly after the work had been completed.

The quantitative data on student interactions shows that Robert makes the greatest contribution to the group discussion across the activities. David always talks almost as much except in Activity 4. Cassie's contributions decrease over the observations and Sarah's contributions increase as the talk of a work related nature increases.

Social roles have a great impact on the types of talk used by this group, with three of the students acting as promoters of distraction the group spend most of their time engaged in off task talk. Where cumulative talk does develop, the tasks have been structured in a way that helps the members of the group to become contributors of content knowledge and encourages them to share their ideas with each other. This mixed sex group does not have a dominant leader, or a mediator of group interactions and this could be why the group

spent most of its time in off task talk. There is little talk developing concepts and little knowledge building. The boys do dominate the discussion in this group and there is a lesser contribution from the girls, although the boys are not critical of the girls in any way. Asking the teacher for help is often a characteristic found in all-boy groups, but this group do this. One possible explanation for this is that it is linked with the fact that the students are working as individuals and therefore want the teacher to talk to them as individuals, or they may simply not value each others opinion. In mixed sex groups, boys have been found to work independently and this is supported to some extent here but there is also evidence that Sarah works independently as well, this could be because Cassie does not take part in any discussion of work with her, throughout the extracts Cassie and Sarah never work together as a pair within this group of four whereas Robert is seen to work in a pair with Cassie, where he is off task (Extract B4) and in a pair with Sarah where he is talking about his work (Extract B6).

I move on now to look at the similarities and the differences between Group A and Group B.

Comparing Group A and Group B.

The talk for both groups shows two similarities; cumulative talk is used by the groups to discuss the results of their observations and to review their existing ideas about science. They both also use technical talk to organise the task with similar percentages of time being spent by both groups on technical talk; so it could be said that they spend similar amounts of time organising themselves to work but then the boys go on to work and the mixed sex group do not.

There are more differences between the two groups: Both show that their talk in science is affected over the activities; with the talk in Group A being affected by the social conflict that develops in their group, where collaborative talk about work decreases. The talk in Group B is affected by

the task, where this is more structured by the teacher; it leads to an increase in collaboration (at least between Sarah and Robert) and an increase in the talk about work. One possible reason for this is that in the mixed sex group the students worked as individuals, a feature found as typical of boys in group work (Murphy 1998, She 1999). The structure of activities 3 and 4 made it more difficult to work in this way and so encouraged the students to work together. The boys (Group A) did not seem to be so affected by task, in terms of overall talk about work, but conflict was noted in this group. This again is a feature of boys working together that has been found by other researchers (Murphy 1998), the difference, maybe, for this all boy group is that the conflict was resolved and they went on to work together collaboratively without intervention by me. This could be explained by the personalities of the boys who are all calm students and good team players.

Group A, develop an intersubjective perspective by sharing their understanding and possessing common knowledge. They use their joint experience, joint activity and collective remembering to develop their intersubjectivity allowing a community of learners to develop. Their talk shows that they are working within a framework that could be described by Mercer's ground rules for exploratory talk. They have not been taught these but seem to have an innate awareness of them. Group B do not develop an intersubjective perspective, they do not share their understanding or engage much in collective remembering. They do not appear to be aware of the ground rules for exploratory talk. The reasons for the differences observed here can possibly be explained by features of the individual students themselves: Group A; Sam, Dale, Liam and Stephen are all relatively easy going boys, who are all friends and are confident enough to share their ideas with each other, they are all team players and have the skills to collaborate in other areas of school life. As their form tutor I have seen this in the classroom. I would have expected Group B to be similar, Cassie, Sarah, Robert and David are all friends who, in my experience get on well together socially, and regularly spend lots of time talking and laughing together about their social lives. It does not appear as easy for these students, to have

that same confidence or willingness to share their ideas about science with each other. Collaborative knowledge building has not been found in many mixed sex groups (She 1999, Hogan 1999) and this is a view also supported by this study. It is, maybe, willingness to share ideas that is critical here, the boys in Group A were willing but the students in Group B were not, one possible explanation for this being their mixed sex situation.

Social roles help scaffolding of learning to take place in Group A, process skills can be seen to develop into procedural understanding and this can be used for the development of conceptual understanding to take place. Exploratory talk and interthinking are evident. From the data, Group B can be seen to learn as individuals. One possible explanation for this is that the students in Group B are not willing to share their ideas, but they also do not have a *promoter of reflection* (Hogan 1999) who helps them to use their process skills to develop their procedural understanding. This may be because Robert, David, Cassie and Sarah, cannot do this as individuals or it may by that the group prefer to work as individuals and simply are not used to working in a group and talking about their ideas.

Exploratory talk is only found in Group A, and then is only evident when the group are developing procedural and conceptual understanding. Social talk is statistically significantly different between the two groups[21], for Group A, it is only found during conflict, after work or when the task is difficult. For Group B it is the main type of talk in Activities 1 and 2 and after work in Activities 3 and 4. The individual nature of working in Group B would be a disadvantage in the development of exploratory talk.

Collaboration develops in Group A because they have a joint frame of reference for talk to take place within (their common knowledge) and when this breaks down they have Dale as a mediator of group interactions who can lead the group back to collaborative talk, using humour. There is a lack of collaboration in Group B, one possible reason for this is that they do not

[21] Student's t-test shows this to be significant at p=0.05.

possess a group leader and they do not base their talk in their common knowledge. This may be due to the nature of the individuals in Group B; all of the students are naturally dominant (the loudest students in this class) and all of them being together means that nobody appears able to lead the talk. The fact that they are all good friends, and nobody is leader in this situation, may lead to nobody acting as leader during their work in the classroom; they maintain the same roles in the group in social and work situations.

Conflict forms part of the discussion in Group A and is found in its three forms, cognitive, procedural and social. Cognitive conflict is needed to get the group talking about ideas, and encourages cumulative and exploratory talk, with procedural and social conflict inhibiting talk of this nature. Conflict does not form part of the discussion for Group B, even when they talk about their ideas Sarah and Robert do this in a cumulative way where conflict of a cognitive nature does not develop. This could be symptomatic of the nature of their friendship group; they generally get along well and do not argue socially, this may well lead to them being unwilling to disagree about their conceptual understanding. The nature of their friendship group may well be impacting upon their classroom talk in a way that I had not considered. I anticipated that, as good friends, they would be able to manage cognitive conflict when it occurred during their talking about ideas, but, if conflict is not a natural part of their friendship group they may have difficulty with this in the classroom. As groups, I have experienced Group A resolving social conflict outside the classroom but I have never known Group B to fall out with each other at all.

Interestingly, Group A in this study appear to show some of the characteristics of a single sex girl group, in that they are a successful group; resolving conflict and becoming highly collaborative. They develop their conceptual understanding about science and do not let their conflict affect this. This group show that single sex boy groups can be successful. The mixed sex, Group B, in this study is not as successful. This is found in other studies researching the affect of gender on small group work although, this

mixed sex group do not have a dominant leader, there is no conflict and the boys do not dominate the girls. One of the reasons they are unsuccessful, is that they do not have a *promoter of reflection* (Hogan 1999) to help them to use their common knowledge to develop their ideas, through their talk and they do not share their ideas with each other.

Moving on from this study – advice for teachers

I can offer advice to other teachers not only about how to use small group work as a pedagogical approach but also how they can investigate their own concerns in their classrooms. That is, using an ethnographic approach to collecting data, enabling them to become more reflective practitioners, both improving their craft and their abilities to evaluate and reflect upon their own practice.

Guidelines for practitioners – using small group work as a pedagogical approach.

In advising teachers about using small group work as a pedagogical approach, from this detailed analysis of the two groups engaged in talk in the classroom it seems that small group work can be used as a pedagogical approach for supporting learning in the science classroom, but that it must be planned carefully and monitored for effectiveness. The planning needs to include considerations about the type of task, ability to talk and social mix of the groups and the monitoring needs to be focussed upon the type of talk that the students are involved in and the social roles and relationships as they develop over time. The advice I offer to teacher is in two parts; firstly advice on how to set up small group work in the classroom to encourage productive talk and secondly how to monitor this in practice. This advice would be of importance to teachers generally, but specifically will be important to teachers involved in starting the teaching of new GCSE specifications where small group work is a suggested pedagogical approach to promote development of students' scientific literacy skills. The findings from the literature suggest that, the productive talk the groups need to be engaged in, for learning to take place in science, are cumulative talk and

exploratory talk. Cumulative talk is needed for students to review their ideas in science and discuss their results from investigations (they use their process skills in science to do this) but this needs to develop into exploratory talk for conceptual understanding and new ideas to be discussed.

The first piece of advice for teachers is that, for group work to be successful at **promoting learning** in science; cumulative and exploratory talk need to be encouraged. The findings of this research give several indications for teachers that will enable them to do this successfully in practice:

- The timing of the talk in small groups.

If small group work is to be used I would still introduce it in the same way to the students; as a specific part of the lesson where they are told that they are to be involved in **talking** about science. This is important so that they are not distracted from their talk by, for example, writing their ideas down. For exploratory talk to develop the students need to be focused on their talk and their ideas. In this study, exploratory talk develops through the conversation; the students do not start group discussion and go straight into a period of exploratory talk. It is therefore the case that they need to be focussed on their conversations and fully engaged in them. The students in Group A were observed to be talking and not writing, but the students in Group B were writing instead of talking during Activities 1 and 2, this may have distracted them from their talk and contributed to the individual nature of their work.

- The type of tasks that work best to encourage cumulative and exploratory talk.

The types of task that are successful in developing cumulative talk are those which have an aspect of reviewing ideas within them, for example in an investigative lesson this would be after the practical activity where the group are looking at their results. Another example is where the students

are reflecting upon their previous learning; these tasks will help cumulative talk to be developed.

For exploratory talk to be encouraged; that is new scientific ideas to be discussed, the findings suggest it is an investigative science activity that is best chosen to achieve this. This investigative science activity must include opportunities for the students to use their process skills in science to develop their procedural understanding and from this their conceptual understanding.

If the students are experiencing difficulties developing cumulative and exploratory talk in their groups and the teacher finds this during monitoring, then greater structuring of the task will need to take place. The teacher may have to introduce prompt questions as a means of bringing the group back to the task or involve the students not only in talking about their ideas but collecting them together and writing them down (as in Activity 3).

- The size of the groups and how they are selected to work together.

The literature reviewed suggests that the ideal number of students in a group is four and the findings in this project do not dispute this. It is not the number of students in the group that appears to cause problems for Group B, but the fact that they did not share their ideas. All of the students in this study were confident to talk in their groups, as the quantitative data on individual contributions show. They were therefore more likely to share their cognitive resources, which they will need to do if cumulative and exploratory talk is to develop. My advice for teachers (and the approach I would take in my own classroom in the future) is that: the students are allowed to select their own groups; but teachers need to be aware that single sex groups often work more collaboratively in the classroom; this view is supported by the literature and my own findings. My project shows that single sex boy groups can be successful and the literature reviewed suggests that single sex girl groups are often highly

collaborative[22]. These single sex groups though, must be able to resolve conflict.

- The development of guidelines to encourage exploratory talk.

The students need to be encouraged to share their cognitive resources with each other and work together in a collaborative way. As is shown in this research and by Wegerif (2002) some groups have an innate awareness (the single sex boy group in this study) and some do not (the mixed sex group). In the future I would develop an introductory lesson at the start of the intervention where the group carry out a reflective activity where they consider the important features of their group work if they are to talk about their **ideas in science** (similar to Mercer's (2000) work to develop *talking rules)*. In the plenary of this lesson I would lead the discussion to develop these group rules and display them in the classroom. At the start of the work in small groups I would review them with the students. In effect, the findings of this research suggest that it would be of benefit to some students to teach them these 'rules'. I would advise teachers that this is time well spent in helping the groups to become collaborative quickly and to a greater extent. I would go further than this and also display some key phrases (either on a permanent notice board or written on the whiteboard) to use in discussion for example:

I think . . .

What do you think?

How do you know?

Could you explain that?

How does this link to the observations?

That's good.

I agree.

I don't agree because . . .

Using phrases like these will help the students develop exploratory talk.

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[22] Due to the limited number of tape recorders it was not possible to research a single sex girl group in the main part of this study.

- Social roles and their impact upon talk.

Teachers will need to know their students well for group work to be successful. If the students choose their own groups the teacher may well have to leave themselves the opportunity to make adjustments to the groups; if in his/her view the students have organised themselves into groups that are clearly inappropriate. The critical social roles, from this project, seem to be promoters of reflection and mediators of group interactions. Groups appear to need a student who can act as a mediator of group interactions if conflict occurs (that can be conflict of a cognitive, procedural or social nature) and to develop higher percentages of cumulative and exploratory talk. This need not be always the same student but someone who can act in this role should it become necessary and keep the group focussed on the task, Richmond and Striley (1996) would describe this as an inclusive leader.

A student, who is capable of acting as a promoter of reflection, is also important; this allows the students to use their common knowledge to help them develop exploratory talk and is necessary if cumulative talk is to be used to review existing ideas in science. This promoter of reflection will refer the group back to their joint experience (that is the practical task or the teacher introduction to the activity) and their collective remembering (their previous work in science). It is important if the group are to be able to use their common knowledge that the groups are left unchanged for a period of time to help this to develop. The teacher can only do this though, if monitoring shows that the groups are working together successfully. Teachers will need to monitor the groups to see if these important roles are being fulfilled. Ways in which teachers may do this are discussed later.

- Developing a community of learners.

The ideal situation is where the small group develops its own community of learners in the classroom. These communities need a more experienced other who is capable of bringing the group forward in their scientific understanding; this will require the development of exploratory talk where

cognitive resources are shared. This would suggest to teachers, that each group, will need to be mixed ability but over a small range. The groups will ideally have students with overlapping ZPDs, but are mixed ability in the sense that one student is more knowledgeable than the others. It is important to note that the more knowledgeable other needs to be prepared to share this with the rest of the group and hopefully, through taking the advice offered above on teaching the ground rules for exploratory talk, this will be the case.

A community of learners using cumulative and exploratory talk is the ultimate successful group for learning to take place in the science classroom.

Guidelines for practitioners - carrying out research in their own classrooms.

Practitioners can interpret the research methodology of this study; from this it can be demonstrated that teachers can teach and research in their own classrooms if they adopt an ethnographic, unstructured approach. Teachers can practice making observations and recordings, identifying key events and adding field notes as appropriate. As an insider they have unique insights to offer into the naturally occurring processes in their classrooms; into the pupil-pupil and pupil-teacher interactions. They can overcome problems with bias by always locating their work within current fields of research to validate their findings or by working in collaborative research groups with other teachers.

Successful teachers reflect upon their teaching, evaluating it with a view to improving it, so they can further support the learning of their students. In order to carry out research in their own classrooms, the reflective teacher must identify an aspect of their work they are keen to find out more about how it impacts on the learning of their students. This aspect needs to be clarified through the process of observing the learning of their students in certain situations and then attempting to account for this. Thus, there is a

progressive narrowing down of the focus onto an aspect of learning so that teachers can find out more about it. Once they have identified their focus, they must think about ways to collect data in as natural a way as possible. The advice I would give to teachers is to use video or audio recording to collect data and to tell the students in general terms what they are interested in finding out about.

During the data collection, the teacher could monitor the students if this is required in their research (to give them more information about the aspect they are focussing on). Through the use of audio and video recordings the teacher, who is an insider, can overcome bias by being able to review their classroom after the event. Having the data as a hard copy of interactions means that the teacher can review it on a number of occasions, to increase the reliability of their observations, that is checking that their observations are supported by their data and are not just their opinions of events. They could also ask another teacher to analyse the tapes and increase the validity of their work. The data needs to be analysed as soon as possible after it is collected, so that if the teacher needs any aspect of the data clarifying, they can ask the students about it, possibly through the use of informal interviews with individuals or groups. This will also help to overcome bias, as the teacher will also have the students' ideas about the interactions that have taken place and their views on what they meant when they used particular phrases or words. From this, the practitioner researcher can then go on to analyse the data providing other teachers and the research community with rich descriptions of the data from their classroom, presenting findings to help others improve their own teaching and aid them to reflect upon their own craft; as well as making a further contribution to the academic debate in the area under investigation. They can also work with other teachers to form a collaborative enquiry group, comparing their observations with those of other teachers will help to validate their findings.

I move on now to provide advice for teachers in how to monitor small groups in the classroom and start by describing the features of a successful small group acting as a community of learners in the science classroom.

Moving on from this study - advice for teachers in monitoring small group work.

A successful small group in the classroom might demonstrate the following key features that could be observed by a teacher monitoring small group work:

- All of the students are engaged in the classroom talk and they all appear to be positive about their group work. This could be noted by a teacher watching the group and how they interact together.
- The group clearly use the data it has collected or its observations as the basis for discussion of ideas in science. This will show that the group members can reflect upon the task set, or their data, and that at least one member of the group is acting in the role of a promoter of reflection. The teacher could monitor this by asking the group how they arrived at the ideas they have developed either during their small group work or the plenary of the lesson.
- Procedural and social conflicts do not develop to a level where the teacher has to intervene. Either, because observations of the group behaviour show that their group work is deteriorating or from being called over by the group. If the teacher does not have to intervene then the group may have students there who are capable of acting as mediators of group interactions.
- The group will only ask the teacher for help when they have tried to resolve a problem for themselves. The teacher can monitor this by when he/she is called over to the group, asking the students if they have talked together about the 'problem' and, if they have, helping them, and if not, then giving them the opportunity to talk about it.
- In the plenary of the lesson the group will demonstrate their learning in science and will have met the learning objectives as set

out by the teacher at the start of the lesson. That is, their group contribution will be of the type the teacher expects, with consideration being given to the ability of the students.

- As individuals, assessment of the students work on a day to day basis through formative assessment and at the end of units in the summative assessment the students will be showing progress in terms of their achievement in science i.e. their level according to the guidelines set out in the National Curriculum.

If all of the above monitoring shows that these key features of group work are being met then successful group work is developing in the classroom.

Teachers can also monitor the groups in other ways; on a lesson by lesson basis or at the end of a period of time e.g. the end of the unit of work or the end of a half term. On a lesson by lesson basis the groups will need to be monitored and the teacher will need to take action if the groups are to develop as communities of learners as described above. Advice on how to do this is detailed in the table in Appendix d.

What should teachers avoid in setting up small group work in the classroom?

In this study, the single sex group of boys did successfully develop as a community of learners over the course of the observations. This is because the nature of their group work possessed the features described above in how teachers should set up small group work in the classroom. In helping teachers know what to avoid then it is useful to reflect upon what made the mixed sex group unsuccessful and what teachers could do to help and resolve this.

The main difficulty experienced by the mixed sex group was that collaborative group work did not develop. The main reason for this, in my view, was that there were too many promoters of distraction (Robert, David and Cassie) and that Sarah was unable or unprepared to mediate the group

interactions and bring them back on task. In this project, having the more vocal members of the tutor group, all together in one group did not work. This had the cumulative effect of distracting each other even more and not working unless their talk was far more structured by the teacher. This group would have benefited from a lesson where they were introduced to thinking about their talking rules and using the key phrases described above and emphasis being placed on the value of talk. This group were similar in ability to the single sex group of boys and so the issues here were not to do with scientific understanding but social relationships. Although, it could be observed that a major stumbling block for this group, in Activity 1 and 2, was in the development of their procedural understanding from their process skills. It is important to note that Robert, David and Sarah though, did develop a rule without the help of the others. It is a warning to teachers here, of the very real and significant impact that social relationships and social roles can have upon learning, when students work in small groups. What is also interesting to note, is that as three of the group completed the task set by the teacher as individuals, maybe, in their view they did not need to talk in their group to complete their work. One possible explanation is that the task did not challenge them. Here the goal for the individuals seems to be to complete the task, not to work together to do it. They did not respond to the teacher's emphasis on **talk** in small groups.

I would advise teachers that, if they have a group like this in their classroom, to follow the advice above and work with the students to help them develop their talk, within the framework of the agreed talking rules of the class. If this makes little difference and they still act as a typical adolescent group then the groups will have to be reconstructed. These students could be placed, as individuals, with a successful group of four and monitor the impact of this. The advice from this research and the literature seems to be that mixed sex groups are not successful, as often as single sex groups, in developing collaborative group work. If they do occur they need to be carefully monitored and changed if necessary.

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Moving on from this study – questions still to be answered.

There are several questions that arise from the advice given to teachers above. If research did address these questions then, a fuller picture of group talk as it happens in ordinary classrooms would be provided and teachers would be even better informed to use small group work as a pedagogical approach in their teaching.

- This research has identified that investigative science seems to be the best type of task for exploratory talk to develop. It would be interesting to know if there were other types of scientific tasks that allow students to develop exploratory talk. For example, can it be developed in other types of science activities, not just practical investigative science? Is the same effect noted when groups talk about ICT based simulations of investigations? Are they able to use their procedural understanding if they have not carried out the procedure? This is important when pressures of the curriculum, lack of resources, safety considerations and ever increasing availability of this data and pressure to use ICT in the classroom mean that this is becoming more common. *Ideas and Evidence* is another area of science where students are involved in looking at demonstrations or data generated, historically, by other scientists, for example, Newton. Can students use exploratory talk to discuss their ideas in science when they are provided with written evidence?
- This research has found (along with existing research) that mixed sex groups are problematic. They appear to experience difficulties developing communities of learners in the classroom when the students are adolescents; social issues appear to have a negative effect upon their willingness to share their cognitive resources. Are the problems associated with mixed sex groups mediated when they are actively taught the ground rules for exploratory talk? Do the further interventions suggested in this research, work in practice, specifically with mixed sex groups?

- This research has identified that promoters of reflection are important in group work as a means of helping the students use their common knowledge to support their group talk. To what extent do students who act in the important role of promoters of reflection help in the important task of helping groups to use their common knowledge during the group discussion and are there other factors that also influence this?
- This research has supported the view that mediators of group interactions are needed if groups are to resolve social conflict. How can these students be identified in the classroom and how can this role be nurtured, in the practice of small group discussion?
- From a social constructivist and socio-cultural point of view, this research also identifies that a more knowledgeable other is needed to support talk about ideas in science. Importantly this individual needs to be willing to share their cognitive resources with others. Along with Shayer (2003) I think that research needs to be carried out to support teachers in the important task of identifying students with overlapping ZPDs as a means of organising students into groups in the classroom. What is the best way to organise students to work together, is it mixed ability and if so to what extent?
- This research was on a very small scale, with only two groups being described in detail. The impact of this is that it places limitations on the advice that can be given to teachers; investigating a larger sample, including all girl groups, would mean that these findings could be tested and if the findings are the same they would be more reliable and generalisable for other teachers. It would also be helpful to extend the number of activities and investigate groups over a longer period of time.
- Key Stage 4 would be an appropriate phase to investigate the talk taking place in small groups. A further refinement of this focus (on the Key Stage) may include examining the talk taking place during science lessons that aim to promote scientific literacy skills; enabling the students to understand the issues that may influence their

everyday lives. Small group work is supported by courses such as 21st Century Science and Science for Public Understanding. Classrooms where these courses are being studied would be of interest to researchers carrying out further research in this area.

In order to address these research ideas above, one way forward would be to involve the fellow teachers in my science department in carrying out research in their own classrooms. It would also be possible, through the Heads of Science forum, for other schools to become involved. For this to happen I would need to present the findings of my project to other teachers and agree an aspect of small group work that we could go on to investigate. CPD for teachers would not only include the findings from my project about how to organise group work in the classroom to encourage talk about science, but also how to carry out research in their own classrooms. I would mentor the teachers, to enable them to become practitioner researchers and then we would collaboratively investigate aspects of small group work in the classroom with a view not only to find out more about small group work but also to become a more reflective community of practitioners.

This chapter has reviewed the findings of this research and used this to develop a framework of advice for teachers in the setting up and the monitoring of group work. It has also identified areas where research, still has advice to offer for teachers, to further support them in developing their teaching in science and for the development of small group work as pedagogy in the classroom.

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Appendix a.

Below is a table to summarise what different authors have said about how boys and girls work in mixed sex and single sex groups.

Table A:

Single Sex Group Boys	**Single Sex Group Girls**	**Mixed Sex Groups**
Boys prefer to work together (Swann 1992)	Girls prefer to work together (Swann 1992)	
Boys rate themselves as least successful (Matthews 2001)		Generally unsuccessful in promoting learning (Hogan 1999)
More conflict found (Murphy 1998)		Boys more likely to dominate the discussion and equipment (Swann 1992. She 1999)
Can be found to work as individuals (Murphy 1998)	Able to think in real world contexts and think strategically for each other (Murphy 1998)	Girls make less contribution to the discussion (Swann 1992)
Increased talk about conceptual understanding (She 1999)	Talk mainly based around developing procedural understanding (She 1999)	Least time engaged in talk developing concepts, little knowledge building (She 1999, Hogan 1999)
Often work as individuals rather than a group (She 1999)	Successful and highly collaborative (Arvaja et al 2002)	Girls can remain on task, a more dominant leader is likely to be found (Arvaja et al 2002)
Ask for the help of the teacher rather than ask each other (She 1999)	More likely to initiate interaction with each other (She 1999)	Boys more likely to be critical of girls and less likely to negotiate. Boys are less likely to discuss ideas without arguing. (Swann 1992, Scanlon 2000)

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Appendix b

Below in table 1 and table 2 are profiles of the individual students who took part in this project.

Table: 1

Student	Profile
Dale	Dale is a friendly, quiet boy who gets on well with others. He is always smiling, Dale wants to please and he has a lovely sense of humour. In class, Dale is reluctant to offer his answers in the whole class situation but will work well with others in a group. He is a good team player. Dale likes to talk about his ideas but is less keen to write them down in his book, written work is often left unfinished. Dale does complete practical tasks on time.
Sam	Sam is a more vocal member of this group. Sam is always keen to offer his answers during whole class discussion. Sam is an able scientist, who likes to share this knowledge both verbally and in his written work. He always completes tasks on time.
Liam	Liam is a quiet, friendly and happy boy with a good sense of humour. He is a very able scientist and his test scores show he is the most able student in this group. Liam will rush through written work. He is a team player who likes to share his ideas verbally with his peers. Liam volunteers to share his ideas in whole class discussion and does so confidently and well. Liam completes tasks on time.
Stephen	Stephen is an exceptionally quiet student. He is very reluctant to share his ideas in a whole class situation, often talking very quietly if he is asked to. Stephen is a calm boy and a good member of a team. Stephen always completes tasks on time.

Table: 2

Student	Profile
Cassie	Cassie, identified from her NCT score, is the least able student in this group. She is a loud student who is capable of more than she actually gives. This is particularly reflected in her written work. She is a good practical scientist who completes this type of activity. She can be distracted by others but generally works well. She likes to be part of a team and as an individual will make little contribution to whole class discussion.
David	David is a lively character with a good sense of humour. He likes to be the centre of attention and is always keen to offer his ideas in whole class situations. He likes practical tasks and working in small groups. He needs to be working with other more fastidious students if he is to complete tasks on time. David gets along very well with others.
Robert	Robert is an able boy who is reluctant to demonstrate this in whole class situations but does like me to know this! He has no interest in competing with his peers. He gets on well with others and regularly completes tasks on time. He likes to get things right and does take pride in his work. He shows little interest in practical work and will sit back and let others carry this out.
Sarah	Sarah is a very able student; her NCT scores identify her as the most able student in this group. She works well with others and adopts a calm and measured approach to her work. She always completes work on time and it is completed to the best of her ability, Sarah is not a competitive student. She is a friendly, happy girl and a firm friend of the others in the group.

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Appendix c

This appendix details the categories of talk, with examples from the transcripts, to show how they have been developed for the purpose of this study.

- *Disputational talk*

Here one individual in the group will keep asserting their own point of view and refuse to listen to the ideas of others. This individual may start to see others in the group as a threat and there is a possibility that this type of talk may lead to confrontation. Collaboration and intersubjective perspective are threatened if this type of talk is evident. The extract below is taken from Activity 3 where the boys (Group A) are brainstorming their ideas about acids and alkalis and writing them down on the poster, as described earlier in this chapter.

Liam	*pH7*	Liam carries on the discussion about neutral substances, here he links the term neutral with a value on the pH scale. The boys are trying to add to their poster (during Activity 3) a fact about the colour U.I. paper changes in neutral liquids.
Sam	*Why the heck have you put that?*	Sam questions why Liam has written pH7 on the group poster.
Liam	*It's pH7!*	Liam, in a surprised way, says that he has written pH7.
Stephen	*pH7 is neutral. Yea Sam!*	Stephen supports Liam, telling Sam that pH7 is neutral.
Sam	*If something is neutral the colour of the paper . . .*	Sam reads what has been written on the poster so far.

Liam	*is green, isn't it?*	Liam completes the sentence, offering the idea that U.I. paper changes green with neutral liquids.
Sam	*No will not change*	Sam disagrees with Liam.
(Silence for 3 seconds)		
	The paper will not change.	Sam restates his idea and writes it down on the poster, (the poster collected from the group shows Sam's idea written down).

For the purposes of this study, *disputational talk* is defined as above, where there are occasions where an individual in the group does not listen to the opinions of others but holds on to their own point of view. This use of *disputational talk* is not quite as strong as Mercer's, for whom the individual may maintain their own point of view more forcefully than in this instance.

- *Cumulative talk*

The talk here is constructive, non-competitive and uncritical. Knowledge accumulates as the conversation continues. The following extract is taken from Activity 4 where the boys and girls (Group B) have got their questions from me and are starting to answer them. Robert starts by asking the first question.

Robert	*Do solids, liquids and gases . . . gas flow? Liquids and gases do. Do solids, liquids and gases keep their shape?*	Robert reads the question and then answers it himself. He goes on to read out the second question.
Sarah	*Solids do . . .liquids and gases don't.*	Sarah answers quickly this time.

Robert	*They just fit whatevers. . . they're put in.*	Robert adds more information to Sarah's answer, he extends her idea using his own words to express his understanding.
Sarah	*The shape of the container.*	This elicits a response from Sarah who gives a more scientific explanation.

The students then go on to the next question. Here it can be seen that the students' knowledge about the nature of the shape of solids, liquids and gas is accumulating as the talk continues. It is talk of this nature that has been categorised as *cumulative talk* in this project.

- *Exploratory talk*

This is constructive discussion, where ideas are talked about with relevant information being offered for joint consideration. Reasoning is visible in the talk with alternative ideas being justified and the group progressing jointly in their understanding. Key words that indicate this type of discussion are, ***because, if, why, I think***. The students here may be talking explicitly about scientific concepts. The following extract demonstrates this and is taken from Activity 2, where the boys (Group A) have completed the practical task as described earlier in the chapter and have started to talk about their results.

Stephen	*Yes but the question is . . What do blue and red litmus paper test for?*	Stephen reminds the group what they are trying to find out. He draws their attention back to the question set by the teacher
Dale	*What do they test for?*	Dale repeats the second half of the question. One possible

		explanation for this is that Dale is unclear about what the question means and so is thinking out loud.
Stephen	*I don't get it . . .*	Stephen shares with the group that he does not know what the question means either.
Liam	***I still think** it's all the red ones are lower on the pH and all the blue ones are higher*	Liam uses the term ***I think*** indicating exploratory talk, goes on to share his ideas with the others.
Stephen	*That's what I was trying to say . . .**because** I was looking at this.*	Stephen agrees with Liam, he uses the word ***because*** and goes on to explain that he was looking at the results from the practical tests.
Liam	*Shall we go with that?*	Liam asks the group if they agree that his conclusion is a summary of the observations from the practical tests.
Stephen	*I don't know . . .*	Stephen seems unclear.
Sam	*All the blues are higher than the reds . . . The blues are higher than the reds.*	Sam repeats Liam's idea twice, one possible reason for this is That he is thinking out loud.

The group go on to discuss this further. This short except is provided as a description of *exploratory talk* as it is used in this study.

- Technical talk

This can be talk about the equipment that the students are using or the group organising themselves to carry out the task. It is the talk that the students use to manage the group activity. It does not relate to the development of procedural understanding or conceptual understanding in science. An example is provided here from Activity 3, the boys and girls (Group B) are brainstorming ideas about *Metals and Non-metals* and writing them down on their group poster.

This extract is from the start of the activity:

David	*Divide the page in half.*	David suggests that they divide the poster into two halves as a way of organising their facts.
Robert	*Why?*	Robert asks David to explain further.
David	*Then metals in one colour . . anyone got a rubber? Doesn't matter it's in pencil crayon. C'mon tell me what to write.*	David explains that they can they use two colours (one for metals and the other for non-metals? (this is what they were seen doing (noted in field notes and seen on the collected poster). He tells the others to tell him ideas to write down.
Robert	*I've already give you one.*	Robert draws the groups' attention to the fact that, he has given an idea already.

Here the talk helps the group to get organised to carry out the task. It does include any talk about their ideas in science. This is technical talk as it is categorised in this study.

- Off Task Talk/Social Talk

This is talk that does not directly relate to conceptual or procedural understanding of the activity the students are carrying out. It is talk about social activities, issues outside the classroom and other students or can even be talk about science that is not directly related to the task that the students are working upon or talking about the task in a way that distracts the students from it.

The extract below is taken from Activity 3, the boys and girls (Group B) have stopped writing on their poster and have started to talk about other things not related to their work.

Robert	*Aarg . . Look at that, who likes my pencil case.R2J No denying it 666 is the devils number.*	Robert draws the groups' attention to his pencil case. He is looking at what he has written on the outside of it.
David	*Why R2J? Year 2K innit!*	David asks him why he has written R2J when it is the year 2K
Robert	*R2J . . .Year 2K*	Robert does not answer, he repeats what David has said.
Sarah	*2K stand for millennium.*	Sarah points out that they are talking about the new millennium which starts in a few weeks.
David	*Big 2K*	David's comment adds little further.
Robert	*So that's the RJ millennium*	Robert claims it as his

millennium!

Here the talk serves no purpose in the development of ideas about science. It is talk of this nature that is categorised as off task or social for the purposes of this research.

The two further phases of group discussion found are:

- Quiet Time

These are periods in the group discussion where there are silences.

- Other

This category accounts for any interactions with other people in the classroom, including the teacher and any other students who join in with the group during the group discussion.

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Appendix d - Monitoring small group work

Lesson by lesson monitoring of group work.	**Intervention needed to help small group work to develop.**
Identify the students not engaged in **talk.** Observe the groups and identify anybody, for example, writing, tidying up practical equipment or involved in disruptive behaviour.	Talk to the group about the guidelines for talk and then continue to monitor. If individuals cannot work in the group together then the groups will have to be changed in some way.
Are the group calling the teacher over for help, if so, of what type; to resolve conflict and social issues or to help with understanding of scientific ideas?	If the help is with scientific understanding (cognitive conflict) then work with the group and act as the more knowledgeable other. If this continues to be a problem then the group may have to be changed to put into the group a student who is more knowledgeable. If the problem is procedural conflict, encourage the group to resolve these themselves by reflecting upon the task. If social conflict occurs help to resolve but be aware that groups may need to be changed if this continues.
Visit the groups and join in their talk. Possibly have two focus groups (out of seven to work with during the lesson) and observe if they are using their procedural understanding to develop conceptual understanding in science.	Act as the promoter of reflection if no one is doing this. Remind them that they have to think about their observations and the procedures they used to collect the data.

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Lesson by lesson monitoring of group work.	**Intervention needed to help small group work to develop.**
Are the guidelines for talk being observed? Are the key phrases displayed around the classroom being used by the focus groups?	When working with them, remind them and draw attention to them to encourage their use.
Monitor the learning outcomes in the plenary of the lesson and in the individual students' written work.	Groups may need to be changed if learning is not occurring.
Monitor learning from test data (summative assessment).	Individuals may need to be moved to a more appropriate group with students of a similar ability.

Periodically the teacher could monitor the groups using a questionnaire to monitor other important issues that the teacher may not observe during the lesson by lesson monitoring. Importantly how do the students feel about working in small groups?

- Are all of the students making an equal contribution to the group talk?
- Do they feel that, as a group, they are following the talking rules?
- Do they feel that this group work is helping them to learn?